JPRS-UEQ-88-004
4 NOVEMBER 1988

FOREIGN
BROADCAST
INFORMATION
SERVICE

JPRS Report

Science & Technology

USSR: Engineering & Equipment

Science & Technology
USSR: Engineering & Equipment

JPRS-UEQ-88-004 | CONTENTS | 4 NOVEMBER 1988

Aviation and Space Technology

Optics, High Energy Devices

Nuclear Energy

Non-Nuclear Energy

Turbines, Engines, Propulsion Systems

Mechanics of Gases, Liquids, Solids

Industrial Technology, Planning, Productivity

High-Speed Holographic Method Proposed for Flaw Detection

18610039i Kishinev SOVETSKAYA MOLDAVIYA in Russian No 194 (16550), 14 Aug 88 p 3

[Article by F. Trishin]

[Text] Hidden flaws in a helicopter blade, motor-vehicle tire or any other product can be detected after its picture is carefully examined. Special holographic equipment and an unusual film have to be used for such picture-taking, of course. This film was developed on the basis of semiconductors, under the direction of L.M. Panasyuk, head of the chair of electronics at Kishinev State University and a meritorious scientist of the Moldavian SSR. The film's high sensitivity and 'dry' developing process make it possible to detect the slightest flaws in a material under study, in one or two seconds. In industrial conditions, this can be accomplished with the aid of a computer, without stopping the assembly line.

A. Barladin, one of the authors of this development, proposed to an ATEM correspondent: "We will conduct an experiment with a welded joint of a pipe in your presence. First we will photograph it in the normal state and then following heating and an impact, or under pressure in which the product changes shape by fractions of a micron and vibrates. The two images lie in a single exposure. An interferogram—a kind of geographic map with surface roughness designated by lines—is created as a result. The irregularities that you see on it indicate cavities and other defects hidden deep inside the product.

"This method permits nondestructive testing of the quality of materials and joints which cannot be probed with ultrasound due to their nonuniformity and multilayer structure. It also does not require special conditions, such as unusual lighting, noiselessness and constant temperature, and it can be widely employed in various branches of the economy."

FTD/SNAP /08309

UDC 531.36:521.1

Effect of Charge Asymmetry of Rotation of Shielded Body in Geomagnetic Field

18610210b Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian No 22, Oct 87 (manuscript received 2 Sep 84) pp 64-69

[Article by A. A. Tikhonov]

[Abstract] Rotation of a body inside a cylindrical electrostatic shield around the Earth along a low equatorial orbit is considered, taking into account that an electrically charged shield moving through the geomagnetic field becomes a source of Lorentz forces which together with gravitational forces influence the rotation of such a body with shield about their center of mass. Two systems of coordinates with a common origin at that center of mass are selected, an orbital one and an inertial one, whereupon the center of the shield is assumed not to coincide with that center of mass so that the charge distribution becomes asymmetric. Stability of equilibrium positions in which the axes of both systems are correspondingly collinear is analyzed on the basis of a closed system of differential equations derived from the Euler and Poisson equations. The analysis reveals that charge asymmetry reduces the number of possible equilibrium positions to less than six but widens their stability range. In addition, the frequencies of oscillations about the equilibrium positions are increased, and may be greater than the maximum possible oscillations in pitch angle for a symmetric charge distribution. Figures 2; references: 6 Russian.

02415/09599

UDC 533.601.18

Aerodynamic Characteristics of Thin Bodies in Rarefied Gas

18610210a Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian No 22, Oct 87 (manuscript received 22 Mar 84, after revision, 23 Oct 86) pp 46-50

[Article by V. S. Naritsa]

[Abstract] The dependence of momentum exchange coefficients on the local value of the Reynolds number is established, in approximate form, for thin bodies in a rarefied gas. On this basis are then calculated both drag and lift coefficients for a triangular plate and a semi-infinitely long plate as well as for a slender cone, also as functions of the Reynolds number appropriately defined in each case. These aerodynamic characteristics are found to qualitatively identical for the semi-infinitely long plate and the slender cone. Numerical evaluation of these characteristics with the aid of regression analysis, in lack of adequate experimental data, and on the basis of Fisher statistics reveals that both coefficients increase with a sharper peak within the 1-100 range of the Reynolds number as the angle of attack is increased. The author thanks R. G. Barantsev for guidance. Figures 2; tables 1; references: 9 Russian.

02415/09599

UDC 535.36:621.372

Frequency Conversion of Radiation From Industrial Solid-State Lasers Due to Stimulated Raman Scattering in Compressed Hydrogen

18610225a Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 11, Nov 87 (manuscript received 12 Dec 86) pp 6-8

[Article by V. G. Bespalov and M. A. Meshalkin]

[Abstract] An experimental study was made concerning feasibility of a small-scale frequency converter for radiation from solid-state lasers, specifically those produced in the USSR, on the basis of stimulated Raman scattering and maximization of its efficiency. Following a preliminary evaluation of various cells with compressed gas in them and of focusing lenses with various focal lengths, a 20 cm long cell with a 2.5 cm inside diameter containing compressed hydrogen was selected for an OGM-20 multimode ruby laser and, for comparison purposes, a GOM-1 single-mode ruby laser. The multimode ruby laser emitted 694.3 nm radiation in pulses of 0.4 J maximum energy and 20 ns duration, with a beam divergence of 5 ang. min. Focusing onto the cuvette was done through a lens with 20 cm focal length, a cofocal lens being placed on the exit side. Measurements were made with one calorimeter through a beam-splitter wedge of K18 glass on the entrance side and with three calorimeters through a dispersing prism followed by another lens on the exit side. As the H_2 pressure was varied, first and second Stokes components (976 nm, 1640 nm) and anti-Stokes components (539 nm, 440 nm) were recorded at corresponding excitation threshold energy levels. The results indicate that 25 atm is the optimum H_2 pressure for maximum conversion into anti-Stokes components with an approximately 3 percent efficiency, preferential conversion into the first Stokes component requiring a somewhat higher H_2 pressure. Figures 4; references 7: 6 Russian, 1 Western.

2415/12223

UDC 531.72

Plotting Surface Topology During Inspection for Deviations From Planarity by Method of Oblique-Incidence Interferometry With Superpositon

18610225b Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 11, Nov 87 (manuscript received 6 Jan 87) pp 10-14

[Article by Ya. O. Zaborov, A. G. Seregin, and Yu. I. Chudakov]

[Abstract] Interferometric inspection of large optical surfaces for deviations from planarity is considered, oblique incidence of light with use of an autocollimating interferometer being proposed as preferable to conventional normal incidence (as used in the Fizeau scheme or Zygo interferometers). The process of collocating diametral segments of a large surface with largest dimension several times larger than the dimensions of reference specimens and interferometer lenses is formalized in algorithms and programmed for automation ensuring complete coverage of the inspected surface by superposition of subapertures, a subaperture being the largest surface segment coverable in one shot. The method was tested on a circular quartz plate 200 mm in diameter and 40 mm thick, this plate being also inspected for comparison with an IZK-464 Fizeau interferometer. Decoding of the interferograms and plotting of the surface topology have also been programmed for automation. Typical results obtained by collocation and by interferometry of discrete spots all over the surface or by an approximation of the latter procedure indicate the advantages of oblique incidence and collocation, the precision being improved by use of a white-light interferometer and tying the inspected surface to three base points 120 deg apart. Figures 4; references 11: 6 Russian, 5 Western.

2415/12223

UDC 681.7.658.520.1.56

Control and Optimization of Technological Processes in Automated Shaping of Optical Surfaces

18610225c Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 11, Nov 87 (manuscript received 6 Oct 86) pp 18-21

[Article by A. P. Bogdanov]

[Abstract] Some time ago (September 1984) the author proposed a method of finishing optical surfaces with a small tool or an ion beam. Mathematical formulation of this technological problem as a problem of control and optimization takes into account nonuniform surface wear as the tool or beam center dwells at a fixed point, with the minimum mean-square deviation from the required final form serving as the optimality criterion. Analytical solution of this problem by successive approximations followed by numerical solution for surface diameters of 300-700 mm and tool or beam diameters of 40-100 mm (5 min on a YeS 10-45 computer, 15 min on an SM-4 minicomputer) indicate the possibility of a highly convergent technological process with 99 percent of all surface energy concentrated within a dissipation circle 3 ang.sec wide before processing and 0.2 ang.sec wide after processing. The calculations have been made for a tolerance not exceeding three times the standard deviation, for errors of the most intricate surface with an area either smaller or large than the tool or beam dimension, and for a symmetric Gaussian current density distribution in the case of an ion beam. The results confirm that there is an optimum technological solution to the problem of surface finishing control. Figures 3; tables 1; references 19: 14 Russian, 5 Western (1 in Russian translation).

2415/12223

UDC 539.1.074:621.383.811

Quadrantal Photoreceiver

18610225d Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 11, Nov 87 (manuscript received 29 Oct 86) pp 30-31

[Article by V. M. Balebanov, E. A. Vitrichenko, S. K. Kulov, A. V. Lamanov, Yu. A. Roze and A. N. Tsagolov]

[Abstract] The "Kozerog" quadrantal receiver of visible radiation is described, this position-sensitive device being useful for such purposes as determining the center of gravity of a light spot. It consists of feeder optics including a photocathode, a pair of microchannel plates in a herringbone configuration, and four other electrodes. A light spot is produced on the photocathode 17 mm in diameter. The focusing electrode forms and electronic image of this light spot on the first microchannel plate. The pair of microchannel plates amplifies this image by a factor of 10^6-10^8 and transfers it onto the plane of two quadrantal anodes. The fifth electrode behind the pair of anodes is grounded. The performance of this photoreceiver is determined by the dark current, which should and does decrease in time to a negligible residual level, as well as by the light-signal characteristic and by the coordinate sensitivity. The dependence of the electric signal on the light intensity should be and is linear over a wide range of anode current and the coordinate sensitivity is linear within 0.025 mm over the 1 mm range on both sides of the original position of the light spot. The linearity ranges and thus the dynamic range are maximized by optimization of the electric circuitry. An aluminum film deposited on the first microchannel plate will decrease the dark current and also lengthen the life of the photoreceiver. Figures 4; references 6: 3 Russian, 3 Western

2415/12223

UDC 681.7:621.373.826

Estimating the Stability of Optical Systems Under Action of Laser Beams

18610225e Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 11, Nov 87 pp 45-46

[Article by A. P. Gagarin]

[Abstract] The stability of an optical system under action of a laser beam is evaluated, for an estimation of the probability of its radiative breakdown, taking into account the different locations of system components relative to the laser spot and the different breakdown thresholds of system materials. Assuming that breakdown of any one component constitutes breakdown of the entire system, energy calculations are made on the basis of given laser beam and radiation pulse parameters with an index of radiative vulnerability defined as indicator of the breakdown risk. Numerical results are obtained accordingly for two objectives, an MTO-500 (with components made of K8 glass, TK6 glass, F1 glass, TK20 glass, TF1 glass, black-annealed steel). Figures 1; tables 1.

2415/12223

UDC 621.378.325:531.76

Angular Oscillations of Object in Interference-Type Laser Vibrometer With Narrow Measuring Beam

18610224a Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 12, Dec 87 (manuscript received 3 Mar 87) pp 2-5

[Article by V. M. Aranchuk]

[Abstract] Measurement of linear oscillations of an object is complicated by the angular oscillations which are invariably also present. The method of two-beam laser interference with a "cat's eye" system and corner reflectors is analyzed for the effect of these angular oscillations of the object, such oscillations not significantly changing the directions of the reflected beam but shifting it laterally. A system which compensates these lateral beam displacements while still using a narrow measuring beam is synthesized and its performance is compared with that of the "cat's eye" system. The proposed laser interferometer contains a beam-splitter cube, a lens, two plane mirrors, and a photoreceiver. The prototype built for an experimental evaluation included also a signal processor and indicator. Oscilloscopes and the measured amplitude of linear oscillations, linearly dependent on the amplitude of angular oscillations with a "cat's eye" system, indicate a high degree of compensation with the amplitude of linear oscillations almost independent of the amplitude of angular ones. Changes in fringe intensity and contrast during angular oscillations of the object have been eliminated and the systematic instrumental error is thus appreciably reduced. Figures 3; references: 7 Russian.

2415/12223

UDC 621.383.4:537.312.5

Coherent Detection of Optical Radiation With Bipolar Photoconductors

18610224b Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 12, Dec 87 (manuscript received 23 Feb 87) pp 9-10

[Article by Yu. Ya. Kozlovskiy and L. N. Neustroyev]

[Abstract] Optical ranging and detection of fast moving objects with coherent radiation by either heterodyning or homodyning is considered, the large Doppler frequency shift of echo signals requiring fast-response photoreceivers and bipolar photoresistors such as p-type $Cd_{0.2}Hg_{0.8}Te$ with ohmic contact tabs characterized by

fast ambipolar drift of electron-hole pairs being particularly suitable for this application. The performance of a single-cell photoreceiver with a multi-element photosensor array is analyzed on the basis of this mechanism, the depthwise mean concentration of excess charge carriers being determined from the continuity equation in the drift approximation. A photosensor array in the plane of the image is synthesized accordingly, the magnitude of the radiation flux which impinges on any one sensor element depending on the size of the exit pupil of the objective and on the drift length. This dependence is calculated for the two extreme cases of a coherence radius for the signal radiation in the image plane respectively larger and smaller than the dimension of such an element, the Helmholtz-Smith theorem being used in the first case and Taylor series expansion of the exponential term after a change of variables being used in the second case. References 8: 3 Russian, 5 Western (3 in Russian translation).

2415/12223

UDC 621.384.326.28

Optical Probing of Inhomogeneities in Weakly Turbid Atmosphere

18610224c Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 12, Dec 87 (manuscript received 19 Feb 87) pp 11-12

[Article by E. V. Pikkel, V. D. Samoylov and M. S. Chukin]

[Abstract] Optical probing of inhomogeneities in an absorptive and dispersive aerosol atmosphere is considered, the theory of this method being based on the integrodifferential equation of radiation transfer describing propagation of light through a weakly turbid atmosphere. This equation is solved approximately for the space-time distribution of luminance in the photodetector plane, assuming a spherical inhomogeneity located in a plane perpendicular to the light path anywhere within both radiator and receiver apertures on a common optical axis. The solution yields the power of an echo pulse as a function of time and the pulse shape, reflection of a Gaussian pulse by an inhomogeneity shortening its rise time and lengthening its decay time dependently on characteristics of that inhomogeneity. Figures 1; references 7: 5 Russian, 2 Western (in Russian translation).

2415/12223

UDC 53.082.5

Optical System of Two Rectangular Angle Mirrors and Its Properties

18610224d Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 12, Dec 87 (manuscript received 6 Mar 87) pp 18-20

[Article by L. V. Pinayev]

[Abstract] A system of two rectangular angle mirrors on both sides of an object is considered, such a mirror being capable of rotating the image of an object and a system of two being capable of parallel shifting of a base line. The mechanism is analyzed according to laws of geometrical optics, using the matrix-vector method, for the cases of simultaneous and sequential rotation of the two mirrors. Rotation of each alone has the property of multiplying the image rotation angle by twice the number of reflections. With the object stationary, the image rotation angle is a measure of the mismatch between the corner edges of the two angle mirrors. Both sensitivity and accuracy of the mismatch angle determination are proportional to the number of reflections and independent of the distance between the two corner edges. Figures 3; references 1: Russian.

2415/12223

UDC 621.79.02.002

Ultrasonic Cleaning of Optical Parts Without Wiping Prior to Deposition of Coatings

18610224e Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 12, Dec 87 (manuscript received 26 Dec 86) pp 26-28

[Article by A. V. Demin and I. V. Petrov]

[Abstract] An experimental study of ultrasonic cleaning and subsequent desiccation of optical glass (K8, K18) without wiping prior to deposition of reflective coatings was made for an evaluation of this technology and five surfactants. The cleaning process consisted of two stages. For preparatory cleaning, removal of sticking resins and protective varnishes, 100 percent Meton surfactant in an organic solvent was used. For final cleaning, removal of all residues and dust as well as grease spots and paper traces, the following were tried: 1. alkalinic 5 percent solution of TMS-57 surfactant in water with boosting additives, 2. acidic 3 percent solution of Fokus-74 synthetic surfactant in water with organic additives, 3. 1 percent solution of acetic acid in water. The duration of preparatory cleaning at a temperature of 20-25°C and of final cleaning at a temperature of 20-25°C or 45-50°C was 3-4 min each. Wet clean surfaces were desiccated with a 0.003 percent solution of ABDMch1C_{17}-C_{20} cationic surfactant in water by slowly lifting the part from the beaker. The reflection spectra of treated glass parts were compared with those of glass parts which had been conventionally cleaned, first in acetone and then in solution of a chrome mixture, and desiccated by wiping with ethyl alcohol through a cotton cloth. These spectra as well as surface examination indicate advantages of wipeless cleaning in terms of effectiveness, in addition to the simpler technology, 1 percent solution of acetic acid being most preferable for final cleaning. Figures 1; tables 1; references 12: all Russian.

2415/12223

UDC 535.824.127(088.8)

Centering Chuck With Variable Pivot Point

18610224f Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 12, Dec 87 (manuscript received 10 Feb 87) pp 38-41

[Article by V. V. Kolchin, V. A. Balabanovich, I. N. Vlasenko and A. V. Smolyak]

[Abstract] For alignment of lenses with widely different radii, a centering chuck has been designed which features a variable pivot point and intermediate arbors of minimum but standard lengths. It includes a set of regulating screws, a set of face plates, a threaded ring for changing the pivot point, a sleeve, a set of levers on a fulcrum each, a set of ball joints, a guide rod, a guide bar, a spring washer, and two wedge rings, also two dials with 1 mm and 0.01 mm scale divisions respectively. The principal performance characteristic of this chuck, namely dependence of the pivot point excursion in either direction on the distance between face plate and stationary lever fulcrum, is calculated on the basis of the kinematic scheme and its geometrical analysis. The heavy weight of the chuck, 8.25 kg, as well as its 150 mm largest diameter and 147 mm length limit its application primarily to machine tools with vertical spindle. Figures 4; references 1: Russian.

2415/12223

Soviet Secrecy in Nuclear Industry Despite Openness

18610279 Moscow LITERATURNAYA GAZETA in Russian No 29, 20 Jul 88, p 12

[Article by Sergey Ushanov under the "World of Science" rubric: "Two Years After Chernobyl: Dissenters Welcome"]

[Text] The major accident which happened two years ago in the fourth power generating unit of the Chernobyl nuclear power plant continues to hold the attention of mankind. But it is not only necessary to speak and write about the most critical period of the disaster and the difficult and dangerous work of cleaning up the accident: a comprehensive study of the causes leading to the Chernobyl incident is also essential. Only by realizing the sources of the tragedy shall we be able to prevent similar misfortunes in future. Only by understanding all our past and present mistakes can we come to a guaranteed safety of our nuclear power industry. Humanity today cannot renounce the energy of nuclear power plants, and it is not appropriate to think about shutting down the nuclear reactors. Instead, we should think about making them safe, the measures that are needed for this purpose, where best to build such stations, and how to resolve all matters in dispute.

And we are indeed discussing such issues today. What a nuisance he was to everyone there! The secretary of the party committee of the I. V. Kurchatov Institute of Atomic Energy (IAE) even coined a phrase: "The institute deserves a well-earned retirement from Comrade Zhezherun."

"The men of science, who even in the highest administrative positions do not lose their love of cogent and witty words, must surely have relished this pronouncement....This spring, like every year, the birds are chirping happily in the thicket outside the institute, enjoying the warmth. The young leaves are bright green. The sun, waking from its winter sleep, feels quite summerlike, producing the pleasant fatigue of a vacation. Spring will burst into bloom this year. The second placid spring since the Chernobyl accident."

Lev Petrovich Feoktistov, assistant director of the IAE, glancing at the exuberant spring outside his office window, stated coldly: "If you want to write something in your newspaper (he warned), just remember that the institute will be able to respond appropriately. For 20 years now, Zhezherun has been complaining everywhere. His complaints have been checked out and thoroughly answered. And there is no point in stirring up the passions once again. I am absolutely against exciting the emotions without cause (he continued). This is not an issue which the press should be exaggerating. There are plenty of other subjects."

Indeed, our topic was clearly disagreeable to Feoktistov. At first, he absolutely refused an interview ("I have nothing to add to what we have already written hundreds of times in the various departments"). I then asked him at least to furnish the correspondence between the executives of the institute and my main character, the troublesome I. F. Zhezherun, when Feoktistov suddenly agreed to meet. Provided the interview would be conducted without Zhezherun. It is very hard to talk to Zhezherun (he sighed over the telephone). He is such an excitable person.

Skimming through the correspondence between Zhezherun and his superiors, I thought: Yes, he is excitable, and he acknowledges no authority. For example, there was the following incident. The director of the IAE, A. P. Aleksandrov, wrote a final decision on his certification appeal: "Ivan Feodosyevich, you are 72 years old, and I feel that a reassignment from senior scientific colleague to scientific colleague is quite appropriate, given your present work fitness. Another possibility is retirement. Think about it." The director had indeed approached the matter in an informal way, cordially, even with touching concern for his subordinate. But instead of being grateful, Zhezherun for some reason struck out against those wishing him well. Here is what he writes in a letter addressed to the party conference of the institute: After all, I am much younger than him [the director], and it is much easier for me to manage a group, than it is for him to manage the institute! And Chernobyl is not my fault. On the contrary, as far back as 1965 I insisted on a program of experiments which would have enabled discovery in good time of the design flaws that made the RBMK dangerous.

What indelicacy! And what conceit! By the way, whenever Zhezherun talks about himself, instead of his subject, his words are modest. As a scientist, I do not perform wonders (he wrote in one of his letters), but my work is conscientious, and always has been. "Conscientious work" is, perhaps, rather decent for the present day. But the more than 40 years career of Zhezherun at the Kurchatov Institute have left their tracks in his service record: for example, he is a doctor of physical-mathematical sciences, a holder of the USSR State Prize, and has also received the Order of the Red Banner of Labor and the medal "For Outstanding Work." In the official evaluations he is known as a qualified specialist with more than 100 scientific projects to his credit, and it is mentioned that he was often elected a member of the party bureau of his section and of the department committee of his trade union. But none of this matters now: the administration of the institute sees him as a person actuated by "the extremely unusual need to write letters to every department, to complain and criticize." And it is true, of all our needs so disagreeable to the administrators, the need to criticize is the most unbearable. "As I am writing to you, there are four volumes of his writings in front of me, on no less than 1000 pages (states the assistant director of the IAE in a letter to the

minister). There are petitions here to the party committee of the institute, the KPK [Party Supervisory Committee], the Congress of the CPSU, the VAK [Executive Certification Commission], the directors of the ministry, the USSR Council of Ministers."

The office of the director of the institute even has a special dossier "on the Zhezherun matter." On carefully ruled sheets, a hand accustomed to scrupulous scientific report writing has noted the dates, described the subjects of Zhezherun's letters, and presented abstracts of the responses to them. In a separate column is entered the time (in hours) spent on deliberating each response. Unfortunately, in my haste I did not read through all of this startling document of the scientific literature of the 20th century: the remainder would likely have contained complicated formulas and graphs, detailed evaluations of all the critical differential and integral characteristics of such unique item of research, by a no longer young, but still vigorous experimental physicist, a specialist in neutron physics measurements, who came to the institute in 1945, straight from the conquered German city of Berlin, in order to work alongside Kurchatov. To work conscientiously. This, I believe, is the point of his existence. Beyond doubt, the people in charge of the Kurchatov Institute are very serious. A serious person, and what is more, a scientist, does nothing without a reason. He abides by the economic principle of least action, as does Nature, the subject of his study. And in order to extract from the institute superiors such clear signs of attention, as Zhezherun has done, would take something completely out of the ordinary. And this he did. "Chernobyl is not my fault". Remember this phrase from the above quotation. What is he implying? What kind of fault? What could science have to do with it? the surprised reader may ask. We are all aware that the Chernobyl tragedy happened as the result of gross mistakes by the operating personnel, infraction of the safe working conditions. What other culprits could there be? Quite true. Still... let us take a simpler situation as an example. If the driver of a bus (the operator), having forgotten what he was taught, foolishly presses the wrong pedal and the bus explodes, killing people. Who is to blame? The driver? Of course, but not him alone. The designers of the vehicle will also have to answer before the law—those who, relying on the strength of the instructions, forgot that only the laws of nature can be counted on absolutely: even if we want, we cannot break them. Shrewd Western companies, understanding what the consumer wants, apply the label "foolproof" on even perfectly safe "manual" household appliances, meaning protected against improper, clumsy handling (frankly stated, against a fool). And no matter how many levers you pull at random, or how many buttons you push, the machine will not break down or run out of control. This has been assured on the drawing board.

But the reactor of a nuclear power plant is not a harmless kitchen appliance or even a heavy bus filled with people. It carries not just an elevated risk, but an extreme risk. A risk for all of humanity.

We all know now that on the fateful night of 25/26 April 1986, at the fourth power generating unit of the Chernobyl AES (with reactor of type RBMK), owing to gross infractions of the safe operating procedures a chain of human mistakes and tragic happenstances led to a terrible disaster: the reactor temporarily went out of control. But let us hear Zhezherun, speaking about what few know. In a letter sent one and a half months after the accident to the chairman of the commission investigating the causes of the accident, he writes: This is not a wild coincidence, it was possible for this to occur with the RBMK reactor. All reactors of this type are fundamentally at risk of explosion, since they have a sizable positive steam reactivity factor. In other words, presence of steam in the reactor core increases the evolved thermal power. And this, in turn, increases the quantity of steam. The circle is closed and the power begins a precipitous buildup, and suddenly the reactor runs out of control. This is just what happened at Chernobyl.

It is important to note that Zhezherun also pronounced these ominous words concerning the RBMK reactor prior to the disaster. Other physicists (even members of the IAE) also spoke on the same subject. But for some reason (why?), the nation did not hear them. And it was more than just talk. Physicists knew that 11 years prior to the accident an instability of the RBMK reactor had been experimentally discovered at the Leningrad nuclear power plant. Consider this particular point: instability in the mass produced nuclear reactor, instability not in the hazy speculations of theory, but in reality, at an AES in operation....In late 1979, the magazine NOVOYE VREMYA (No. 18) printed a factual article "The Lesson of Three Mile Island" concerning the accident at the American nuclear power plant. This included the statement of the director of the IAE, A. P. Aleksandrov: "In the USSR, scientifically validated standards and rules of nuclear and radiation safety have been worked in the design, construction and operation of the power plants, and supervisory bodies have been created for their safety. In terms of safety, we can say today with complete confidence that adoption of the appropriate precautionary measures is enabling the development of the nuclear power industry."

This was 7 years before the Chernobyl accident....The article, referring to Western experts, named those directly responsible for the American accident, the leaders of the nuclear and power industry of the USA, "who allowed construction of nuclear power plants based on substandard designs." It also reported the immediate social impact: "In West Germany, where there are 13 nuclear power plants in operation, a group of physicists visited Chancellor Schmidt and lodged a protest on account of their imperfect security system." The Soviet physicist I. F. Zhezherun did not visit government officials—in this year, he was pondering and wrote a letter to the party committee of the Institute of Atomic Energy under the heading "Regarding the Tendencies of Monopolism in the Nuclear Reactor Sectionjand the Work Style." I shall present several brief excerpts from

this (so that our physicists will not have to prostrate themselves entirely before our West Germany colleagues): "Regrettably, one must admit that the spirit of Kurchatov is almost entirely vanished from the section.... Discussion of scientific organizational matters has been moved to the narrow sphere of conferences of the executives and scientific technical councils, the makeup of which is also limited and specially chosen to suit the executives.... There is not even a shred of personal contact between the section director and the workers: in fact, he is in a building which most of the workers are not authorized to enter...! The present situation...is not conducive to raising the scientific stature and effectiveness of the work of the section. On the contrary, it is susceptible of every conceivable deficiency and omission...." And as the article in NOVOYE VREMYA so well stated: "The accident at Three Mile Island is a harsh and severe lesson, a kind of warning of fate. In theory, there should be no possibility of such accident."

Yet why did we not heed this warning? The pronoun "we" here is, of course, a rhetorical flourish, and nothing more. Not we, but them, those who knew or were supposed to know, whose duty was to anticipate. As a matter of fact, no one even found time to inform us. There is an explanation of course: the period of stagnation, the lack of openness, and so on and so forth. But today, in the era of democracy, today how many of us know what was recounted above? Yet how much has been written, spoken, and filmed about the Chernobyl tragedy! There are novels, stories, films, plays, articles in newspapers and magazines, but the detailed report of Soviet specialists submitted to the MAGATE, the texts of the discussions held there, are not easy to obtain (the report was printed only in the low-circulation trade paper Atomnaya Energiya).

What is more: not only the public at large, but even those working in science have practically no access to detailed information on the causes of the Chernobyl incident. Recently, one of our readers sent us a copy of the table of contents of the American magazine Science, which his research institute had received. There were two articles listed in bold print. One, by a bitter irony of fate, was called "Openness Comes to Soviet Physics," the other "The Nuclear Power Industry After Chernobyl." Who, then, had deemed it necessary to conceal publications on such important subjects from the Soviet reader? Were the Americans ingenuously seeking to divulge our top secrets among us? Most lamentable, this was not 10 or even 5 years ago, but last year.

I can not even believe what I am writing. Still, there are nagging doubts: could it be that those who study, design, and build nuclear reactors are permitted to know only so much about their brainchild? Firsthand information, as it is known. An excerpt from a communication of V. P. Volkov, member of the Kurchatov Institute, to the upper echelons of the Party and State:"The USSR has provided the MAGATE with exhaustive information on the design of AES with RBMK. The causes of the accident are known by the entire world, but in the USSR they are a secret, even to specialists in the field of nuclear power...." On the socalled information day (17 September 1986), the scientific executives imparted their version of the accident.... Not only was discussion forbidden on this occasion, it was not even possible to ask questions. A similar situation occurred at a colloquy devoted to the Chernobyl accident. All this was forbidden to an audience whose activities make it essential to have a maximum of information to prevent the like occurrence in future....As the diplomats say, no comment is necessary.

J. Ahern, the author of the American article surveying the development of the nuclear power industry after the Chernobyl disaster, also views the positive steam reactivity factor of the RBMK as the main cause of the accident. Does this mean that Zhezherun and the other physicists who warned against the dangerous design features long before the disaster were right? Probably so. But here, as in science (as the critics bitterly jest in the smoking rooms of the research institutes), it is not a matter of being right, but more right than the others.

And now, as it begins to emerge that those who enjoy no special authority were nevertheless right, their opponents are already blaming them on this score, saying that their warnings were not strenuous enough. In a letter to the minister, the directors of the Institute of Atomic Energy deftly implicate Zhezherun: "[His] calm assessments of the steam effect became ominous only after the Chernobyl accident." Comrades, I am simply speechless! Do I need to explain that if Zhezherun, during those very years when the director of his institute and the president of the academy were assuring everyone from the pages of NOVOYE VREMYA as to the safety of the Soviet AES, had gone public, waving a poster with the formula of the steam factor, he would have been thrown in prison, and not just retired! And instead of the splendid words "doctor of sciences" and "laureate", quite different epithets would appear in his resume: slanderer, muckraker, renegade. Of course, certain parties will regret that this was not the outcome, but really, one should not express his vexation so openly.

In this same letter, the directors of the IAE, oblivious to the diabolical humor in their words, explain: "The experiments determining the sign and magnitude of the steam effect are carried out directly at the AES reactors when started up. The main findings have been obtained at the first and second generating units of Chernobyl.... The experiments of Zhezherun add nothing to this." No, my learned comrades. Your main finding was obtained at the fourth generating unit. And the experiments of Zhezherun in fact had nothing to do with this.

But the reader is already weary, most likely, from this long string of mutual recriminations. He would like some sort of optimistic final note, so that he may adjust his glasses, fold up the newspaper with a feeling of relief, put

on his slippers and gaze at the ravishing beauty of the color TV set. He would like internal calm, a comfortable belief that complete and final happiness needs only slight effort, "blazing a trail" for the ideas of a persecuted innovator, the hero of the moment in the newspaper article. Frequently, the writers themselves believe in this heedlessly, and infect the reader with their passionate belief. But, as Ilf once said, the radio has been invented, and still there is no happiness.

I shall not pound my breast in righteous indignation and demand that the directors of the Institute of Atomic Energy and the Ministry immediately begin the experiments long since proposed by Zhezherun. This is frightfully easy to do—come out in print with the voice of authority, telling the scientists what to do. Perhaps assistant director Feoktistov was also partially right, thinking Zhezherun's experiments unnecessry (he considers Zhezherun an experimental physicist of the old school, excessively idealizing the situation and trying to solve an extremely difficult problem with far too simple means). I don't know, and it is not my place to judge. Neither do Feoktistov, or even Zhezherun, know the full story: for Zhezherun's program of experiments still have not been fully conducted. But, like every inventor, Zhezherun believes in his idea and continues to assert that the RBMK reactor—mere mention of which suggests the horror of the Chernobyl monster—can still be made safe by design optimization, without forfeiting its other valuable qualities.

Incidentally, no one has yet taken it upon himself to reject his proposals out of hand. In the report of an authoritative commission formed of specialists not part of the Kurchatov institute, there are votes for and against such proposals. Even so, the report concludes with the following remarkable paragraph: "As for the measures which comrade Zherzherun thinks are essential to improve the safety of the RBMK, we should note that his basic proposals have been embodied in the consolidated measures of three official agencies on this matter."

Taking a broader view of the matter, it is clear that the specific proposals of Zherzherun are not the point at issue. Many nuclear physicists are thinking about this problem, which has become vitally important (literally) to all of us after April 1986. Remember: over a dozen RBMK reactors are already (still?) in operation within the Soviet Union. V. P. Volkov, cited above, refers to another member of the IAE, V. A. Ivanov, who around ten years ago (!) proposed a method of modernizing the RBMK, which would also make this reactor more stable in operation. There are ideas aplenty. But to adopt any of the radical proposals would automatically cast in doubt the validity of the long-since approved design, the competence of its executors, as well as that of those who approved it and assured the public of the complete safety of the reactor. And for this same group of people to be working on the problem—how could they punish themselves? That would be too much.

Our paper has discussed the subject of democratization of science so often that, perhaps, it will be boring to some of our readers. Yet here is a case which illustrates that the democratic mechanism of decision making is in no way a luxury, but a vital necessity (even though a burden to some). If our science had democracy, openness, frank and wide-ranging discussions at the appropriate time, we might not have had to live through the gruesome spring of 1986.

I asked assistant director Feoktistov why the directors, being competent administrators, do not avail themselves of those attributes of Zhezherun's personality which are now causing them so much trouble. If a person has a sharp critical insight, is able to "tear apart" someone else's project, and what is more, notices every tendency that is harmful to genuine science and calls it to the attention of the public—is he not a real asset to the institute, even if he is not always right? The timely criticism of such person would guard against so many mistakes and save so much money that he might almost be paid the director's salary, with a separate bonus for each cancelled design, for each administrative decision "retracted." So to speak, a professional gadfly receiving a piece rate. "But why do we need all this?" responded the assistant director. And I thought to myself: they really don't.

But it is essential to us—we who cram into the buses in the morning, fill the lobby of the Kurchatov institute, rack our brains at our desk or crawl through an experimental layout with a wrench, who stand up to the authorities at the scientific seminars and refuse to sign the latest pseudo-scientific fraud, yet who believe that true science is done only with clean hands. Without this, there will be no peace for those who risked their life to work in the contaminated zone around Chernobyl, or to all those still living on this planet.

The guarantee of our safety is not the latest decision by a scientific council, nor even the modification of the reactors. The only trustworthy guarantee is a sign on the doors of the institutes: "Dissenters wanted." And applicants will be found. 12717

Specialists Assess Safety Measures at Ignalina Nuclear Station

18610039f Vilnius SOVETSKAYA LITVA in Russian No 198 (13711), 27 Aug 88 p 1

[Article by A. Gasyunene]

[Abstract] The article reports on proceedings of a meeting of the Lithuanian SSR Council of Ministers which took place on 25 August. The progress of work on making the Ignalina Nuclear Power Station safer and ecologically cleaner was discussed at this meeting, as was the question of whether construction of the station's

third generating unit should continue. Among the speakers were V. Sakalauskas, chairman of the republic Council of Ministers; A. Khromchenko, director of the Ignalina station; V. Kurnosov, a general designer and chief engineer; Yu. Cherkashov, deputy director of the Scientific Research and Design Institute of Electrical Equipment and a general designer; and Yu. Vilemas, director of the Lithuanian Academy of Sciences' Institute of Physical-Technical Problems of Power Engineering.

Sakalauskas recalled that the design and safety of the Ignalina station and research of physical and seismic conditions in its vicinity had been discussed at high-level meetings earlier this year. Khromchenko reported that the initial stage of work on making the station's first and second generating units more reliable has been completed as quickly as possible, and that the two units were operating stably.

Cherkashov commented on modernization and improvement of reactors of the RBMK type and safety control systems for nuclear power stations. He mentioned that the speed with which control elements are introduced into the core of an RBMK reactor has been reduced from 18-20 to 12 seconds, and that a new safety control system is now in operation on all reactors of this type. One of the first of these systems was tested at the Ignalina station. Asked why the capacity of the station's third unit has been reduced from 1,500 to 1,250 megawatts. Cherkashov characterized this step as 'extra insurance', since the safety of even a 1,500-megawatt unit is guaranteed, and the effectiveness of emergency protection systems has increased eight times, according to calculations. Kurnosov called 1,250 megawatts the optimal level which guarantees safe and reliable operation of a generating unit.

FTD/SNAP /08309

Fire in Ignalina Station's Second Generating Unit Reported

18610039e Vilnius SOVETSKAYA LITVA in Russian No 206 (13719), 6 Sep 88 p 3

[Text] Fire broke out on the cable level of the second generating unit of the Ignalina Nuclear Power Station on 5 September, a few minutes before 1:a.m. An automatic fire-extinguishing system went into operation immediately, and the fire was put out in 15-20 minutes. Several control cables about 3 meters in length burned up in the process. An automatic safety system shut down the whole second generating unit literally a few minutes after the fire broke out. Cable restoration work is in progress, and a special commission has been created to investigate the causes of the fire. Radiation conditions at the station and around it have not changed.

At the Lithuanian SSR Main Industrial Administration for Power and Electrification, it was reported to an ELTA correspondent, that a rather complex power situation has developed in the republic. As has been reported, the first unit of the Ignalina Nuclear Power Station is shut down for repairs until 14 October. A generating unit of Vilnyus Central Heating and Power Plant No 3 was not started up on the morning of 5 September, for technical reasons; the Kaunas Central Heating and Power Plant's second turbine is on standby duty because of hydraulic testing of the city's heat-supply systems; and the fifth unit of the Lithuanian State Regional Power Station is operating below full capacity. A substantial electric-power deficit has thus been created. It is being offset by power from the unified Northwest System, to which ourrepublic's power industry is connected.

FTD/SNAP /08309

Safety Equipment Found at Fault in Ignalina Nuclear-Station Fire

18610039a Vilnius SOVETSKAYA LITVA in English No 212 (13725), 13 Sep 88 p 2

[Article by Z. Shupayeva]

[Excerpt] As has been reported, the second generating unit of the Ignalina Nuclear Power Station has been shut down as the result of a fire which broke out on the cable level of this unit.* [* See the Daily SNAP, September 15, 1988, p 4, col. 1]

Two interagency commissions, which are headed by A.L. Lapshin, USSR deputy minister of nuclear power engineering, and Yu.N. Filimontsev, head of an administration of the Ministry of Nuclear Power Engineering, worked for several days at the station.

The commissions have completed their work. Possible causes of the fire are mentioned in documents pertaining to the results of this investigation. The fire probably resulted from mechanical injury to the insulation of a cable at the point of a bend, where the cable route passes from one shelf to another. Prolonged overheating of the cable became possible as a result of passage of an overload current or an external short circuit. Protective equipment failed because it was not sensitive enough.

The direct loss from the fire was 4,000 rubles, and the cost of restoration work is estimated at 15,000-20,000 rubles.

Radiation conditions at the station and around it have not changed.

Restoration work is scheduled for completion on 17 September, and it is planned to put the second generating unit back into operation on 19 September.

For preventive purposes, all points where cables intersect will be coated with a fireproofing compound in order to prevent similar fires.

Coating with the same compound of all cables passing into spaces below the reactor's control-board unit is planned next year, during the period of regular planned repair work on the second generating unit.

FTD/SNAP /08309

Construction of Ignalina Nuclear Station's Third Unit Halted

18610039g Moscow IZVESTIYA in Russian No 245 (22417), 1 Sep 88 p 2

[Article by L. Kapelyushnyy, (Vilnyus correspondent)]

[Excerpt] The Lithuanian SSR Council of Ministers has adopted a decision to discontinue financing construction of the third unit of the Ignalina Nuclear Power Station.* [*See also the Daily SNAP, 12 Jan 88, p 4, col. 1]

Construction of nuclear power engineering facilities requires the highest skill, faultless observance of technological and economic norms, and work of excellent quality. A. Zhukauskas, vice-president of the Lithuanian Academy of Sciences, noted [at the meeting of the republic government] that builders of nuclear power stations can boast of this far from always, sorry to say. Plans for the Ignalina station, which still are not in approved form, originally specified low seismic safety factors. Whereas these plans' calculations were based on oscillations with an intensity of six degrees, an earthquake with seven degrees of intensity was recorded in this area at the beginning of the century. In the opinion of Yu. Sabalyauskas, first deputy chairman of the Lithuanian State Committee for Nature Conservation, a number of violations which occurred during the building of the station's first unit have been carried over to the third unit as well. The designers also have no unequivocal answer to the question of how to preserve the ecological balance of a natural treasure—Lake Drushkyay.

N. Ponomarev-Stepnoy, first deputy director of the Institute of Atomic Energy imeni Kurchatov, reported that this institute has conducted radiation monitoring in the field and charted contaminations at the request of Lithuanian colleagues. With respect to radiation, Lithuania has proved to be a clean territory, particularly in the vicinity of the nuclear power station. But who knows this, other than a narrow circle of specialists? The fact that our population is denied the opportunity of possessing personal radiation monitors also puts people more on their guard.

During the discussion of the problem, it was proposed that work be halted on construction of the Ignalina station's third unit (in which 260 million rubles have already been invested).

Following the meeting of the Lithuanian SSR Council of Ministers, the Elta wire service reported that the republic government, the USSR Ministry of Nuclear Power Engineering (N. Lukonin, minister) and the USSR Ministry of Medium Machine Building (A. Usanov, deputy minister) have decided to suspend construction of the third generating unit until all questions of safety are fully answered, and also to request the USSR Council of Ministers to create a state commission to examine the construction plans and problems of the Ignalina station's third unit.

FTD/SNAP /08309

Plans for Technology Transfer in Thermonuclear-Reactor Project

18610039c Moscow MOSKOVSKAYA PRAVDA in English No 186 (10804), 16 Aug 88 p 3

[Article by A. Kolesnikov]

[Excerpt] This year, countries which took part in the INTOR international tokamak-reactor project have united again for the purpose of developing an international experimental thermonuclear reactor (ITER).* [*See also the Daily SNAP, 13 Jun 88 p 1, col 1]

According to preliminary estimates, this actor will cost 3-4 billion dollars—an unprecedented sum, and an astronomical one for a scientific research unit. Where will it be built?

"The question of a construction site was debated for a long time," related Candidate of Physical-Mathematical Sciences G.A. Yeliseyev, deputy director of the plasma-physics department of the Institute of Atomic Energy imeni Kurchatov. "The final decision will be made later, assuming that the partners do not become disappointed with each other and that they start building the reactor jointly."

"Have problems of an organizational nature arisen?"

"Yes, and we are solving them. We have had to master quickly telefax communication, which we did not have and managed without in the past, and also computer-aided designing systems, which we did have but also got along without for one reason or another. Interaction is on a qualitatively new level in this sense and will, I think, be much enriched by experience of our chief designers: the Leningrad Scientific Research Institute of Electrophysical Apparatus imeni Yefremov and the Moscow Scientific Research and Design Institute of Power Equipment.

"We have been sharing knowledge for a long time; our joint work would be meaningless otherwise. Our contribution to the program, for example, will be a new method of heating plasma by means of microwaves in the millimeter wave band, and also many other developments."

FTD/SNAP /08309

Nuclear Institute Gets New Head Following Probe of Mismanagement

18610039h Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian No 200 (5791), 30 Aug 88 pp 1, 2

[Article by V. Roshchin, (Moscow) correspondent]

[Abstract] The article reports on disciplining of officials of the Belorussian Academy of Sciences' Institute of Nuclear Power Engineering (IYaE) for unprincipled conduct. Attention is focused on maladministration of an IYaE project aimed at development of a nuclear power generating unit employing a new dissociating nitrogen-tetroxide heat transfer agent. This project was allowed to continue for more than 20 years, it is recalled. Tests of a prototype unit were not conducted until November of last year. These tests failed to confirm the unit's operational fitness. Two months later, the project was declared unpromising and the decision was made to shut it down.

V. Nesterenko, a former director of the nuclear-engineering institute, other officials of the institute and its special design bureau and Communist Party committee, representatives of client-organizations, and other parties involved in the project permitted distortion and suppression of facts about the quality of work, dealt too leniently with erring subordinates and took reprisals against critics of the project's results, it is claimed. A case in point involved Vasiliy Nikitovich Yermashkevich, deputy director of the institute. As long ago as 1982, Yermashkevich refused to sign a report certifying the quality of equipment that had been developed and criticized the progress of the project, it is recalled. He was subsequently barred from acceptance examinations, fired from his position as chairman of the institute's technical council, and expelled from the chief designers' council and the state testing commission. P. Budapovskiy, deputy personnel director of IYaE, and E. Pereslavtsev, head of a laboratory, appealed to the Central Committee of the republic Communist Party on Yermashkevich's behalf, and a subsequent investigation confirmed his judgments. However, no action was taken on the situation at IYaE until new heads of the Belorussian academy launched a restructuring campaign. A new institute party committee was elected about a year ago, and deputy director A. Mikhalevich became acting director of IYaE. Even the new leadership proved reluctant to undertake a thorough housecleaning, however.

It is reported in conclusion that V. Sorokin was recently elected director of IYaE and that Nesterenko has been severely reprimanded by the bureau of the Belorussian academy's party committee.

FTD/SNAP /08309

UDC 669.14.018.8:621.181.8

Properties of 10Cr9MoVNb and 10Cr14MnMoVNb Steels for Steam Generator in Nuclear Power Plants

18610182b Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 88 pp 36-41

[Article by I. R. Kryanin, doctor of technical sciences, V. P. Borisov, candidate of technical sciences, I. A. Shchenkova, candidate of technical sciences, and V. G. Shumskiy, candidate of technical sciences]

[Abstract] Two chromium steels 10CrMoVNb and 10Cr14MnMoVNb developed at the TsNIITmash [Central Scientific Research Institute of Machine Manufacturing Technology] NPO were tested for mechanical properties making them suitable as steam-generator materials in nuclear power plants. While quenched 10Cr14MnMoVNb steel has a ferrite-martensite structure with up to 25 percent δ-ferrite, 10Cr9MoVNb contains no δ-ferrite and therefore has a higher impact strength. Specimens of both steels, rods 20 mm in diameter and 15 mm thick 120x220 mm^2 large plates as well 60-200 mm thick forgings and tubes 15 mm in diameter with 2.5 mm wall thickness or 25 mm in diameter with 3 mm wall thickness, were tested for the KCV impact value (kJ/m^2) as well as for short-time tensile strength (yield, ultimate) and plasticity (elongation, reduction) prior to and after aging at 475°C for 3000 h, at 550°C for 4000 h, and at 600°C for 10,000 h. Specimens of both steels and welded joints of each were also tested for the stress dependence of service life under static loads and the fatigue limit under cyclic loads. The results of this study justify recommendation of the 10Cr9MoVNb steel, more economical than conventional alloy steels and with better performance than the 10Cr14MoVNb steel, for small-diameter cold-rolled and large-diameter hot-rolled heat exchanger tubing. Figures 1; tables 2; references 10: 6 Russian, 4 Western.

2415/12223

UDC 621.311:621.039

Dependence of Optimum Plant Cycle Parameters in Nuclear Power Plant on Mode of Plant Operation

18610161 Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 3, Mar 88 pp 59-63

[Article by V. Ya. Onishchenko, candidate of technical sciences, Ye. A. Antonov, engineer, and A. V. Meshcheryakov, engineer, "Red Banner of Labor" Saratov Polytechnic Institute]

[Abstract] Plant cycle economy in nuclear power plants is analyzed comparatively for optimization in three different modes of plant operation: 1) plant operation

covering total electrical base load around the clock, 2) plant pulled into operation for coverage of partial base load during night period but covering full base load during remaining hours, 3) load-following plant operation, to match changes in base load with constant reactor power, reactor pumping energy into a heat storage plant during minimum-demand periods and being aided by heat storage plant during maximum-demand periods but covering full base load during normal periods. The total normalized cost per cycle is assumed to consist of three components: fuel cost, weighted variable part of investment cost, and additional cost of ensuring precise coverage of the given load demand curve, which are all functions of the minimum, maximum, and baseload AES power levels. The cost equation is analytically optimized, and plant-power operation. Optimization of the temperature of regeneratively preheated is feedwater. Figures 1; references: 1 Russian.

2415/12223

Committee Hits Neglect of Alternative Energy Sources in RSFSR

18610039b Moscow SOVETSKAYA ROSSIYA in English 14 Sep 88 No 213 (9764) p 2

[Article by A. Korolkov, A. Nemov]

[Abstract] The article reports on results of a recent meeting of the RSFSR Supreme Soviet's Standing Committee on Power Engineering. Implementation of a republic program for employment of unconventional sources of energy in the economy was assessed at this meeting.

Participants in the meeting complained that wind, geothermal and solar power engineering are advancing too slowly in the RSFSR. It was noted in particular that practically no wind energy is being utilized in the republic and that the USSR Ministry of the Electrical Equipment Industry has not organized production of wind-driven generating equipment. The USSR State Committee for Science and Technology's 1989 allocations for work on speeding the advancement of wind power engineering were called inadequate. It was reported that the Pauzhetka Geothermal Power Station is operating at only half of its capacity, and that only isolated solar heating units are in operation in the republic. Local agencies still have not begun to carry out a government resolution calling for solar energy to be used as a substitute for organic fuel in 13 territories. The quality of solar batteries in production was criticized.

Speakers said that administrative and economic reform was proceeding too slowly in the field of alternative energy sources. Concerned agencies lack economic incentives for building needed facilities and producing needed equipment, for example. The USSR Ministry of the Gas Industry, which is the chief ministry in charge of utilization of geothermal waters, was accused of foot-dragging on construction of a heating line from the Pauzhetka thermalwater deposit to an enterprise in Ozernovskiy, for example. The USSR ministries of the building-materials industry (Minstroymaterialov) and nonferrous metallurgy, which build solar power plants, are said to view their production as no more than a sideline. The USSR Ministry of Land Reclamation and Water Resources was said to be unable at present to implement an official policy for the advancement of wind power engineering, although this ministry's "Vetroen" research and production association is a chief organization for development of wind-driven power plants. Minstroymaterialov's Bratsk Heating Equipment Plant is the only producer of solar batteries in the republic at present, which means that equipment for regions with abundant solar energy has to be imported from Siberia.

It was recommended that a single adminsitrative agency be created under the republic Council of Ministers or State Planning Committee. This agency would coordinate a whole set of projects on the use of alternative energy sources as substitutes for organic fuel. Ministries and agencies were set specific tasks for expanding ecologically clean power engineering in the republic.

FTD/SNAP /08309

Call for Action to Further Large-Scale Solar Energy Program

18610039d Moscow IZVESTIYA in Russian No 249 (22421), 5 Sep 88 p 1

[Article by F. Ivanov]

[Excerpt] There will be 11,000 power plants utilizing solar energy in Azerbaydzhan by the end of the 5-year plan.

This is the task of a large-scale program for utilization of unconventional types of energy, which the republic Council of Ministers has adopted. A. Mutabilov, chairman of the Azerbaydzhan SSR State Planning Committee, told about this new program, which is called "Gyunesh" ("Sun):

"A special association for solar technology for sanitary engineering 'Azsantekhgeliomontazh', has been created in the republic. This organization has the task of designing, producing and installing solar-energy systems. By 1990, 250,000 square meters of solar batteries are supposed to be operating in our republic. Unfortunately, these plans are now on the brink of failure. The USSR Ministry of Nonferrous Metallurgy, which supplies us with solar collectors from which solar power plants are assembled, lacks incentives for producing these collectors. The 'Aztsvetmet' (Azerbaydzhan nonferrous metal) association, which builds them, has no plans for increasing its capacities."

"How advantageous is it now to use solar energy?"

"Solar energy systems are still costly to build. Our designs are imperfect and therefore uneconomical in many respects. Specialists now have to be sent abroad in order to acquire needed experience. On the whole, the time has come for state solution of the problem of utilizing unconventional types of energy, for separate planning of everything connected with them, and for stipulation of state orders for solar collectors. Incentives must be provided for use of solar power systems as a contribution to the cause of conservation."

FTD/SNAP /08309

UDC 621.784.06(088.8)

Quenching of Parts for Power Generating Equipment in Water-Soluble Polymer Medium

18610173e Moscow ENERGOMASHINOSTROYENIYE in Russian No 1, Jan 88 pp 35-38

[Article by V. M. Yezhov, candidate of chemical sciences, S. V. Semakin, engineer, V. V. Svetlichnyy, engineer, A. M. Mazayev, engineer, and Yu. V. Sobolev, candidate of technical sciences]

[Abstract] Replacement of mineral oils with cheaper noncombustible water-soluble polymers as a quenching media reduces the cost of heat treatment, an important item in the manufacture of power generating equipment. One such polymer medium, developed by the Atomkotlomash and TsNIITmash [Central Scientific Research Institute of Machine Manufacturing Technology] NPOs in collaboration with the Izhorsk Heavy Machinery (Turbine) Manufacturing Plant, is based on a sodium salt of carboxylmethyl cellulose. This medium has successfully passed laboratory and factory tests. It was tested on three typical machine parts: 1) plate of 00Cr12Ni3Cu steel, 600x600 mm^2 square and 180 mm thick, 2) two levers made of $34CrNi1MoN_2$ steel, 860 mm long and 240x280 mm^2 in cross-section, 3) shaft made of 9Cr2MoV steel, 2800 mm long consisting of barrel 550 mm in diameter and neck 320 mm in diameter. Each part, except one lever for subsequent mechanical testing, was equipped with Chromel-Alumel thermocouples on the surface and at various depths. In a gas furnace initially at 650°C they were heated first to 680°C and held at that temperature for 1.5-2 h, then to 860-880°C and held at that temperature: the plate for 3-3.5 h, a lever for 7-8 h, the shaft for 10-11 h. They were subsequently quenched in the polymer solution, with the tank at 10°C or 50°C, till their surface temperature had dropped to 100°C: that of the plate within 40 min, that of a lever within 100 min, that of the shaft within 140 min. The polymer concentration was varied for regulation of the cooling rate and various mineral salts were added, also for regulation of the cooling rate as well as for stabilization of the medium. The cooling rate in pure polymer solution was found to be lower than in mineral oil, but to increase upon addition of mineral salts. Mechanical tests after tempering yielded better characteristics (hardness, strength, plasticity, impact value) than those of parts quenched in mineral oil and comparable with those of parts quenched in industrial-grade vegetable oil. Turbine runners made of $R2MoN_2$ tool steel were quenched in this medium with maximum allowable polymer and stabilizer concentrations, their mechanical characteristics and especially plasticity but also impact value at temperatures down to -70°C having been found to be superior. Figures 6; tables 3; references 6: 4 Russian, 2 Western.

2415/12223

UDC 621.165.62-5

Effect of Electrohydraulic Servomechanism on Quality of Steam-Turbine Regulation

18610158 Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 88 pp 5-8

[Article by V. A. Mirnyy, engineer, Yu. V. Nikitin, candidate of technical sciences, and Yu. N. Sokolov, candidate of technical sciences]

[Abstract] Design and performance analysis of a digital electrohydraulic regulation system for high-power steam turbines, based on numerical simulation on a BESM-6 high-speed computer, indicates that a hybrid digital-analog power regulator provides the best process control. In addition, we should expect better interference resistance. Such a regulation system should retain the conventional electrohydraulic servomechanism with analog feedback and have its digital part optimally tuned, the optimum discretization interval being virtually invariant for changes of the feedback factors over the entire practical range so that tuning the regulator during the preliminary startup stage can be simplified. Figures 2; tables 2; references: 4 Russian.

2415/12223

UDC 621.822.5

Effect of Construcition and Assembly Flaws on Static Characteristics of Gas-Static Thrust Bearing With Self-Stabilizing Cushions

18610216 Moscow MASHINOSTROYENIYE in Russian No 6, Nov-Dec 87 (manuscript received 8 Oct 86, after completion 30 Jun 87) pp 81-88

[Article by G. A. Luchin, Leningrad, and V. M. Kosenkov, Nikolayev]

[Abstract] The static characteristics of large gas-static turbine bearings with self-stabilizing cushions designed for heavy loads are analyzed on the basis of experimental data and a theoretical model, small bearings of this sort designed for light loads having been found to perform well. A hermetic air bearing was tested at room temperature under compression loads of 0.1-10 kN, with the supercharge pressure varying over the 0.098-7.06 MPa range and the static pressure varying over the 0.21-1.05 MPa range. Axial displacemnts were measured, "negative clearances" attributable to elastic deformations due to construction and assembly flaws being recorded under heavy loads. The mean clearances were then calculated from these readings. The load capacity of the bearing was determined, after its six cushions had been unequally loaded prior to the test. Theoretical analysis of the bearing characteristics is based on the Reynolds model and a numerical solution of the corresponding steady-state boundary-value problem. This solution, which converged rapidly and was devised to be conservative in its estimate, indicates that elastic strains produced by cushion self-stabilizaiton do not influence the static characteristics of such a bearing but increase the gas flow rate and decrease the load capacity somewhat. Differences between clearances, on the other hand, reduce the load capacity appreciably. Large clearances and light load are conducive to floating and self-excited oscillation of cushions, which must be prevented by design. A rise of the backpressure at constant supercharge pressure widens the range of cushion floating toward smaller clearances, which must also be prevented by design. Figures 4; references 11: 10 Russian, 1 Western.

2415/12223

UDC 531.391

Stability Analysis of Steady Rotation of Vertical Rotor in Hydrodynamic Bearings

18610212 Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 23 No 12, Dec 87 (manuscript received 14 Oct 85) pp 95-102

[Article by N. V. Derendyayev, V. A. Senyatkin, and V. M. Sandalov, Scientific Research Institute of Applied Mathematics and Cybernetics, Gorkiy University, Gorkiy]

[Abstract] Rotation of a vertical axisymmetric rotor in hydrodynamic bearings about its axis is considered, specifically steady rotation at a constant absolute angular velocity, such a rotor being mounted through the bearings on a stationary vertical journal. The rotation is analyzed for stability in the small, on the basis of a two-dimensional model with perturbations causing only circular precession of the rotor axis so that it remains parallel to itself and with a horizontal plane velocity field characterizing flow of the lubricant. The hydrodynamical problem for a viscous incompressible fluid is reduced to a system of first-order partial differential equations with appropriate boundary conditions. It is solved, with the aid of the flow function, for calculation of the hydrodynamic force acting on the rotor. The mechanical problem for a perfectly solid rotor is reduced to a system of second-order ordinary differential equations describing a mass-spring system with damping and is solved with the aid of D-partitioning. Figures 4; references 8: 6 Russian, 2 Western (in Russian translation).

02415/09599

UDC 533.6.011.5

Effect of Angle of Attack on Supersonic Flow Past Axisymmetric Blunt Bodies With Injection From Surface

18610207a Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 5, Sep-Oct 87 (manuscript received 3 Oct 85) pp 95-101

[Article by V. A. Antonov, A. M. Grishin, and F. M. Pakhomov, Tomsk]

[Abstract] Supersonic flow past an axisymmetric blunt body with a power-law generatrix of the surface profile $r=z^{0.125}$ (cylindrical system of coordinates) and with high values of the Reynolds number in the shock layer is analyzed for the dependence of aerodynamic characteristics and the streamlining pattern on the angle of attack over the 0-40 ° range, first without injection and then with strong subsonic local injection from the surface. The corresponding equations of gas dynamics for a closed volume of the shock layer are formulated in accordance with integral laws of conservation, with appropriate boundary conditions at the impermeable surface of the body and Rankin-Hugoniot initial conditions. Numerical solution by the method of finite differences with the Godunov stabilization procedure on a BESM-6 high-speed computer has revealed that increasing the angle of attack from 0 to 10 ° causes negligible changes, but increasing it from 10 ° to 40 ° causes the drag coefficient to decrease monotonically in the absence of injection and to remain nearly constant with a tendency to increase owing to reaction of the injected gas. The metacenter and eccentricity characterizing the stability of such a body under the given conditions have also been determined from the available data. Figures 5; references: 9 Russian.

02415/09599

UDC 533.6.011.5

Force and Moment Characteristics of Supersonic Flow Past Cylindrical Solid of Revolution With Fluid Wing

18610207b Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 5, Sep-Oct 87 (manuscript received 24 Apr 86) pp 102-106

[Article by V. F. Zakharchenko, Yu. Kh. Kardanov, and P. V. Sidorov, Moscow]

[Abstract] A cylindrical solid of revolution in an oncoming supersonic stream is considered, and injection of gas jets into that stream through holes in the lateral surface of the body is analyzed for effectiveness of such a fluid wing. The pressure distribution over the plane development of the cylindrical surface, behind the section passing through the centers of the injection holes and their extensions in the stream has been computed for a typical geometrical configuration with various shapes of the holes but the same equivalent diameter, with a 5 ° angle of attack, with a Mach 1.86 velocity of the oncoming stream prior to its perturbation, and with a c=38.9 ratio of injection pressure to quiescent pressure at the surface. The calculated additional forces and moments characterizing the effect of a fluid wing, means of flight control and stabilization, agree closely with experimental data. Figures 3; references: 5 Russian.

02415/09599

UDC 533.6.011.5:519.63

Aerodynamic Characteristics of Long Cones With Rounded Tips During Intense Mass Transfer

18610207c Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 5, Sep-Oct 87 (manuscript received 6 Aug 86) pp 107-113

[Article by V. N. Karlovskiy, V. A. Levin, and V. I. Sakharov, Moscow]

[Abstract] A long narrow cone with a spherically rounded tip facing a supersonic stream is considered, and injection of a gas with the same ratio of specific heats into the stream from the surface of that tip is analyzed for aerodynamic characteristics. The layer between the cone tip surface and the shock wavefront includes a subsonic boundary sublayer, and the problem is accordingly split into two consecutive ones. The first problem, flow field in the subsonic sublayer, is solved by the method of stabilization in time. The second problem, flow fields in the supersonic sublayer, is reduced to the Cauchy problem for steady-state gas dynamics. The system of equations for the latter is formulated in two systems of coordinates, Cartesian and nonorthogonal curvilinear, for expedient transformations from one to the other. Numerical solution of these problems with the vertex angle of the cone varied from 20 ° to 40 ° and the ratio of cone length to tip radius varied from 2 to 10, with the angle of attack varied from 0 to 20 ° and the initial stream velocity varied from Mach 3 to Mach 7, has yielded the relative decreases of the drag coefficient with increasing total injection rate (referred to the cone base surface) under the various conditions. The results reveal no flow separation during injection. Figures 5; references: 14 Russian.

02415/09599

UDC 533.6.011.8

Effect of Transonic Nozzle Segment on Efficiency of Freezing-in Vibrational Energy in H_2-HCl Stream

18610207d Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 5, Sep-Oct 87 (manuscript received 24 Jul 86) pp 137-142

[Article by V. A. Salnikov and A. M. Starik, Moscow]

[Abstract] Plane nozzles with the subsonic segment in the form of a wedge and with a circularly curving transonic

segment are considered for discharge of mixed H_2HCl streams, and their performance is analyzed for the effect of the transonic segment on the freeze-in of vibrational energy. The analysis is based on the system of two-dimensional transient-state equations of gas dynamics and vibration kinetics for plane or axisymmetric flow of an inviscid and thermally nonconducting gas. These equations are solved for the efficiency of that energy freeze-in in an H :HCl=0.95:0.05 stream at temperatures of 2000-2500 K and under pressures of 5-10 MPa, with the opening angle of the subsonic wedge varied from 0 to 160 ° and the transonic arc having a normalized radius r=1. Calculations are made in dimensionless variables, by the method of stabilization in the third-order approximation with respect to the space variable. These calculations yield the dependence of that energy freeze-in efficiency on the shape of the subsonic nozzle segment, which includes a uniform-section throat segment, and on the shape of the following transonic segment. The results reveal that this efficiency decreases along both segments, the principal cause being the compression shock. The authors thank V. A. Levin and R. K. Tagirov for helpful discussion. Figures 5; references 12: 9 Russian, 3 Western.

02415/09599

UDC 532.526.048.3.011.6

Experimental Study of Three-Dimensional Supersonic Separation Flow Between Plane Cap and Sphere

18610207e Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 5, Sep-Oct 87 (manuscript received 21 Oct 86) pp 166-170

[Article by V. S. Khlebnikov, Moscow]

[Abstract] An experimental study of supersonic separation flow at the surface of a sphere with a needle projecting radially along the axis of the oncoming stream and holding symmetrically a cap at the immersed other end was made, this cap being either a wedge frustum tapering into the stream or one of two different thick disks. Needles of various lengths were used so as to vary the surface-to-surface distance between cap and sphere. Measurements with a Tepler instrument were made in a wind tunnel with a Mach 3 velocity and a Reynolds number of $(1.5\text{-}1.6)\cdot 10^6$ within the test segment, while the flow pattern was photographed with a high-speed camera taking 30 frames per second. Pressure and thermal flux were measured at stagnation temperatures of 300-306 K and 390-396 K respectively, the stagnation pressure being $(4.90\text{-}4.98)\cdot 10^5$ N/m^2. Holes were drilled into the sphere for drainage or for installation of calorimeter probes. Measurements in two parallel planes have yielded a dependence of thermal flux and pressure distribution within the attachment zone on the needle length, with the latter smaller than, approximately equal to, and larger than the critical cap-to-sphere distance, also low-frequency pulsations of the separation zone in the case of a short needle. Figures 3; tables 2; references: 7 Russian.

02415/09599

UDC 532.59

Propagation of Surface Waves Through Layer of Liquid on Porous Solid Base

18610207f Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 5, Sep-Oct 87 (manuscript received 20 Feb 86) pp 183-186

[Article by I. V. Stolyarov and N. G. Taktarov, Saransk]

[Abstract] Propagation of waves along the surface of a heavy homogeneous incompressible fluid on a nondeformable porous solid base is analyzed theoretically, assuming that the solid base with an impermeable bottom surface is thoroughly impregnated. The corresponding system of equations describing filtration of a liquid into a porous medium are formulated in vector form and the velocity potential in the free liquid is assumed to satisfy the Laplace equation, with appropriate boundary conditions of flow rate and pressure continuity at the liquid-solid interface as well as kinematic conditions and the linearized Cauchy-Lagrange integral at the perturbed free surface. The solution yields the amplitude of surface waves and its attenuation as a result of filtration downward. The authors thank Yu. Z. Aleshkov for discussion. Figures 1; references 7: 5 Russian, 2 Western (1 in Russian translation).

02415/09599

UDC 531.8

Control of Manipulator Motion Along Contact Between Gripper and Object

18610208a Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 5, Sep-Oct 87 (manuscript received 5 May 86) pp 41-49

[Article by A. V. Lenskiy, A. B. Lizunov, S. B. Mozhzhevelov, A. M. Formalskiy, and A. Yu. Shneyder, Moscow]

[Abstract] The problem of controlling the motion of a manipulator gripper for maintenance of contact with a stationary object is analyzed and solved theoretically on the basis force and moment adaptation, control of the gripper motion being useful for determining the contour of an object and for tracing the seam on welded joints or the surface finish during automatic technological operations. The equations of motion are formulated specifically for a manipulator which has two orthogonal translatory degrees of freedom in the horizontal plane of its

table, the entire manipulator mechanism consisting of two driving motors with speed reducer each, a rod with gripper, and a force transducer in contact with the object. Control of the drives is sought which will ensure that, after initial contact, contact will be maintained between gripper and object with a contour which is not a priori known. Both rectilinear motion and circular motion of the gripper are considered, in each case being resolved into tangential and normal components. Friction is first ignored and then included, the force transducer assumed to also move in the latter case. Each motion is tested for stability by the method of phase-plane analysis. As the shape of objects becomes more intricate, practical solution of the control problem requires computer experiments. Figures 5; references 12: 6 Russian, 6 Western.

02415/09599

UDC 539.3

Problems in Theory of Shells Related to Characteristics of Modern Structural Materials

18610208b Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 5, Sep-Oct 87 (manuscript received 10 May 87) pp 178-188

[Article by V. V. Vasilyev, Moscow]

[Abstract] The classical theory of thin shells based on Kirchhoff-Love hypotheses is modified by inclusion of nonclassical terms so as to be made also consistently applicable to modern structural, mainly synthetic, materials including multilayer composites with appreciable anisotropy. A shell of an orthotropic material and generally nonuniform wall thickness is accordingly described by the appropriate equations of elasticity in a system of orthogonal curvilinear coordinates, considering that the thickness is small relative to all other shell dimensions. The system of these equations is solved by the method of initial functions which characterize displacements and stresses at points of the initial surface, and which are expanded into Maclaurin series with respect to the normal axis of coordinates. This series can be arbitrarily truncated for approximate qualitative rather than precise quantitative analysis of the resulting finite-order two-dimensional equilibrium equations. The state of stress under the constraint of a zero thickness taper and an infinitely high modulus of elasticity at one edge is calculated, assuming zero tangential displacements along both longitudinal and transverse axes of coordinates. A hollow beam on two hinge supports is considered as a most simple specific example. For comparison, the same problem is analyzed according to the zero-moment variant of this nonlinear theory, where the equations of equilibrium describing physical relations together with the equations describing geometrical relations form a sixth-order system so that the deviation from classical theory allows imposition of constraints on all displacement components at the edge. Figures 4; references 22: 20 Russian, 2 Western.

02415/09599

UDC 533.6.011

Plane and Axisymmetric Configurations in Flow With Maximum Critical Mach Number

18610221 Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 51 No 6, Nov-Dec 87 (manuscript received 3 Dec 86) pp 941-950

[Article by A. N. Krayko, Moscow]

[Abstract] A structure is found for plane and axisymmetric configurations in a flow of ideal (nonviscous and nonconducting) gas with maximum critical Mach number in boundless space or inside a cylindrical channel. This structure is determined analytically on the basis of the rectilinearity property of an acoustic line (Mach 1.0 between two subsonic regions or between subsonic and supersonic ones) and on the basis of the comparison theorem provable with the aid of the maximum principle for subsonic streams. The critical Mach number is treated as a functional of the body shape parameters. The optimum configurations include some with closed generatrices and some with open ones, bow or stern parts of semi-infinitely large plates and circular cylinders, also arrays of symmetric profiles, which satisfy three geometrical constraints deriving from the comparison theorem. Additional constraints are needed in the case of a viscous gas flow. While theoretically a global maximum of the critical Mach number is attainable, in practice only conditions necessary for a local maximum have been satisfied at most. Selection of the best configuration from all possible optimum ones is a problem analogous to synthesis of optimum control. The author thanks V. A. Vostretsov for assistance. Figures 3; references 13: 7 Russian, 6 Western (1 in Russian translation).

2415/12223

UDC 532.595

Hydrodynamic Characteristics of Cavity Partly Filled With Fluid and Containing Pendulum

18610222 Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 6, Nov-Dec 87 (manuscript received 17 Mar 87) pp 91-100

[Article by V. A. Buzhinskiy and V. I. Stolbetsov, Moscow]

[Abstract] Equations of motion are derived by the asymptotic method for an axisymmetric cavity in an oscillating body containing a viscous fluid with a free surface and a physical pendulum with the pivot on the

cavity axis, assuming small linear and angular oscillations of the body. The problem is analyzed in two systems of Cartesian coordinates, one with one axis passing through the pivot of the pendulum and an "absolute' one outside the cavity. The hydrodynamic inertia and dissipation characteristics of such a cavity-fluid-pendulum system with a smooth cavity wall are calculated by the method of finite elements and the Treftz method with corrective functions, whereupon the effect of hoops around the cavity wall acting as barriers and influencing the inertia characteristics is estimated. Numerical results have been obtained on a YeS-1060 computer. Figures 5; references 15: 12 Russian, 3 Western (2 in Russian translation).

2415/12223

Goals in Reconstruction, Tool Renewal by 1990

18610409 Moscow NOVOYE V ZHIZNI, NAUKE, TEKHNIKE: SERIYA TEKHNIKA in Russian No 4, Apr 88 pp 34-53

[Article by V.A. Disichkin: "Technical Reconstruction"; passages in boldface as published]

[Text] The Economics Encyclopedia defines production reserves as the capability of improving the utilization of resources of enterprises as a result of upgrading equipment and technology, organization of labor and production, overcoming bottlenecks, and also putting previously unused production resources into action.

Upgrading equipment and technology is an ongoing process. The fact is that machines and equipment have their physical limits, they get old. The pattern is such that as the scientific and technical revolution unfolds, the obsolescence of fixed capital, especially the active part, shows up before it is physically worn out. Machines become comparatively less productive, and cease to meet new technical and social requirements, i.e., they have to be changed.

There are two main ways to do this. One way is to build new plants. The other is to upgrade the existing production facility on a new technical level. For a long time the economic potential of the nation has been developed chiefly through new construction. About 75 percent of all capital investments have been spent for this purpose, and nearly 80 percent of new equipment has been installed in the shops of newly constructed plants. Such a practice has often led to a decline in capital productivity: the increase in output of goods has lagged behind the increment in production capacities.

In the 12th 5-Year Plan, provision has been made for renewal of up to 60 percent of equipment, and the coefficient of retirement of the active part of capital as a whole with respect to the national economy will increase from 3.2 percent in 1985 to 6.2 percent in 1990, i.e., it will nearly double. The absolute sum of retirement of capital in the current 5-year plan will be 240 billion rubles, as compared with 110 billion in the last 5-year plan. Retooling will enable renewal of more than one-third of the active part of fixed productive capital. The principal condition of retooling is a sharp increase in efficiency of the newly introduced capital as compared with that being replaced. The new machines and equipment replacing those being retired, and the reconstructed shops and enterprises should bring about a multiple increase in labor productivity. Even in the 12th 5-Year Plan, newly assimilated kinds of equipment will have 1.5-2 times the productivity and reliability with respect to similar goods produced. The fraction of equipment being produced for the first time in the total volume of machine building output will reach 13 percent in 1990 as compared with 3.1 percent in 1985. The proportion of machine building goods produced for less than 3 years will double over the same years from 27 to 52 percent. The time required for development and assimilation of new machines will decrease by a factor of 3-4.

By 1990, the fraction of capital investments in retooling and reconstruction of existing enterprises in the national economy of the USSR will increase to 50 percent of total capital investments with strict observance of the rule: the construction of new enterprises and expansion of existing enterprises can begin only when the demands of the economy for the corresponding kinds of goods cannot be met by more complete utilization of the capacities of existing enterprises, and when labor resources are available on the territories of the new construction site.

The economic necessity of such an approach is determined by the fact that capital investments in retooling and reconstruction are paid back on average three times faster than in construction of new enterprises.

The advantage of retooling over new construction is that only the active part of fixed capital is renewed, while buildings and structures are left alone. The production collective of an existing enterprise assimilates new capacities much more quickly than the collective of a new enterprise, which is inadequately organized, and frequently understaffed. Rapid renewal of the active part of fixed capital by retooling of existing enterprises will lower the requirements, and hence the expenditures for overhaul. The fact is that at the end of the last 5-year plan the magnitude of these expenditures in industry reached a third of the volume of capital investments. About half the inventory of metalworking equipment was engaged in repair work. In industry alone, the repair of equipment came to 10 billion rubles, and of this sum more than 3 billion rubles was spent on equipment that was being used beyond the normal service life.

Wide-scale renewal of fixed capital will come not only from elevation of the technical level of machines, but also from increased production volumes. In machine building itself, priority is given to machine tool construction, production of computer equipment, instrument making, the electrical and electronics industries.

Machine tool construction: the "technologist" of machine building. From a logical standpoint, this is completely explainable: no matter what new machine the designers may dream up, it stays on the drawing board until another one is developed to produce it. This other machine—a machine tool, or rather a set of machine tools—must surpass the new machines that it is to produce with respect to all parameters. For example, if geometrically precise and high-finish machining is needed for an aircraft engine, it can only be done on machine tools with parts that as a minimum have the same precision and finish. Right now, machine tools are required that not only give machine builders parts of any complexity, but also do it with savings of materials, expenditures of working time and labor resources.

But in 1980, 216,000 machine tools were made—15,000 less than in 1975. The decline in output has continued: 205,000 in 1981, 195,000 in 1982, 190,000 in 1983, 188,000 in 1984. What has happened? Have the capacities of machine building plants been used up? Are there not enough resources for producing the goods? Or has the national economy been completely saturated with new equipment? No, it has nothing at all to do with a decline in production in the generally accepted sense. It is something else altogether: the changes reflected by the statistics are due to a switch to production of more progressive and complex models equipped with modern automatic control systems, the latest electric drives and other component parts.

Of the roughly 800,000 metal-cutting machine tools produced by the machine tool construction industry, those turned over to the national economy in 1981-1985 included about 50,000 numerically controlled machine tools, more than 200,000 press-forging machines, about 2,000 transfer lines for machine building and metalworking, more than 800 million rubles worth of technological equipment for casting production, a total of more than 900 million rubles worth of woodworking equipment, and more than 5 billion rubles worth of various kinds of tools. The output of NC machine tools increased in 1985 by a factor of 2.4 over 1980, the increase being by a factor of 2.9 for machine tools of the machining center type, while production of industrial robots rose by a factor of more than 6.

There has been intensive renewal of output goods: series production of more than 3,000 kinds of items has been developed and finalized, 1,200 of these items being intended for replacement of those produced previously. Robot systems and flexible manufacturing modules have been put into large-scale production. Among the machine tools that have passed into the national economy are several hundred thousand automatic and semiautomatic specialized high-capacity machine tools. More than 2,000 automatic and semiautomatic lines have been set up for the automotive industry, tractor and agricultural machine building, and other industries.

The changes that are now taking place in machine tool construction relate primarily to dynamic development of NC machine tool production, including robot systems, machining centers, flexible manufacturing modules, and so on. The advent of automatic control systems, microprocessor technology, electric drives and electronic automation in modern enterprises has opened up wide possibilities for automation not only in large-series and mass production facilities, but also in series and small-series production, which comprises nearly three-fourths of the total production volume in machine building.

In recent years, a program of development of precision machine tool construction has been implemented: industry is producing jig-boring machines, coordinate grinders, diamond boring machines, thread grinders, highly automated surface grinders, and so on.

The technical and production capabilities of heavy machine tool construction can be judged from the technical specification of the machines being produced. For example, lathes are produced for machining parts up to 6 m in diameter and up to 30 m long, vertical lathes for turning parts up to 22 m in diameter, gear hobs for making gears up to 12.5 m diameter, planers and planer-millers with table up to 5 m wide. Several models of heavy and custom-made NC machine tools are being produced.

In recent years there has been a considerable change in the structure of forging and pressing equipment. In the overall output of these machines, the fraction of equipment with facilities for mechanization and automation, including automatic systems, has increased from 12 percent in 1980 to 38.6 percent in 1985.

Appreciable changes have been made in development of the production of metalworking tools. There has been an expansion in the use of wear-resistant coatings, tungsten-free hard alloys, synthetic diamonds, and other superhard materials. On Soviet "Bulat" installations, wear-resistant coatings are applied on a wide range of cutting tools. The machine tool and cutting tool industry completely meets the needs of the nation for abrasive and diamond tools; the demand is high, as the technical level of Soviet machine tools for large parts is well known on the world market. The trademarks of the largest enterprises of the USSR are known abroad. Tracer-controller milling, boring and multiple-operation machine tools of the Leningrad Union Production Association imeni Ya.M. Sverdlov are in operation in more than 50 nations. Vertical lathes of Krasnodar Machine Tool Construction Plant imeni G.M. Sedin are being shipped to 40 countries. Lathes of the Ryazan Union Production Association are being exported to more than 60 countries. Many foreign companies are eager to buy heavy and custom-made machine tools such as the milling machines of the Ulyanovsk Heavy and Custom-Made Machine Tool Plant, the vertical lathes of the Kolomna Heavy Machine Tool Plant, and the boring machines of the Novosibirsk Machine Tool Plant imeni the 16th Party Congress.

What will be done by machine tool construction of the nation to mobilize all production reserves?

The following tasks have been set for the 12th 5-Year Plan: raising the productivity of equipment being made by a factor of 1.5-1.6, and the precision of machining of equipment by a factor of 1.2, reducing the specific metal requirements of equipment produced by 12-18 percent, and the specific energy intensiveness by 7-12 percent. There is to be an increase in productivity of progressive kinds of equipment, and their fraction is to be increased from 43.3 percent in 1985 to 85 percent in 1990. The production of NC machine tools with increase by a factor of 2.1, the production of automatic and semiautomatic equipment in 1990 will be 54 percent of the total machine tool output, and it is planned to increase the

production of automatic transfer lines for metalworking by a factor of about 1.8. The production of NC forging and pressing machines will increase by a factor of nearly 3.3. In the makeup of NC equipment, there will be an increase in the production of machining centers by a factor of 6, and of flexible manufacturing modules by a factor of 2.7. To make extra precise housing and base components of machine tools and measuring machines in place of cast iron parts, plans have been made for experimental production of synthetic granite (sintegran) at the Moscow Stankokonstruktsiya Plant of the Experimental Scientific Research Institute of Metal-Cutting Machine Tools, with industrial production at the Kaunas Tsentrolit Plant. This will ensure stable retention of machine tool precision over a prolonged period.

In the immediate future a technological process is to be introduced for checking machine tools and parts based on using laser systems which, with the existing accuracy of positioning of high-precision and extra precise machine tools, will reduce checking time from 160 to 3 hours, i.e., by a factor of 50.

By the end of the 5-year period, composite cutting tools with mechanical fastening of hard-alloy tips will account for 73.5 percent of the total production of hard-alloy metal-cutting tools. There will be a considerable increase in the production of cutting tools with wear-resistant coatings; the proportion of hard-alloy tools of this kind will be 47 percent. By 1990, the following indicators are to be attained with respect to renewal of production: output of goods being produced for the first time in the nation will be 15 percent, and the output of goods produced for 3 years will be 48 percent.

What do these figures tell us? First of all, that production of high-quality equipment as a basis for machine-building enterprise retooling will dramatically improve the efficiency of existing and new plants, and mobilize available reserves. Of course, the machine tool builders themselves have been among the first to start technical reconstruction and retooling. For example, Ivanovo machine tool builders, the initiators of reorganization in the industry, have introduced for themselves in their association an index of "production of the latest goods." This is interpreted as follows: First of all the development of fundamentally new models several times as productive, rather than upgrading preceding models. Second, the machine must have a maximum life of 7 years from the start of production. By that time, it is old. And third, it must be competitive on the markets of industrialized Western nations. The Ivanovo workers have achieved this. Other enterprises of the industry have begun to emulate their experience.

How does one speed up development of new equipment and technology and master their production right in the association? The Ivanovo Production Association has taken a new approach to this problem. In addition to the machine tools, the association sells the customer complete technology so that the purchased equipment can go into production immediately upon installation.

The collective of the association has started something completely new with the introduction of an effective special design office in the very procedure of fabricating new equipment. The all-inclusive composite method introduced at the association, in which drawings for the first parts and components are turned right over to the technologists dramatically compresses the time needed for producing new equipment. A finished machining center is now turned out in a maximum of a year and a half, and often considerably sooner.

During the 11th 5-Year Plan, the association increased the volume of salable goods by 74.5 percent, and raised labor productivity by 76.9 percent. These indices have been attained with a reduction in working staff, and without increasing capacities. The association has been awarded the Order of Lenin for achievement of high production indices, and for accelerated development and organization of series production of equipment. The work of the collective has been commended at a session of the Politburo of the CPSU Central Committee.

In 1986 the Ivanovo Machine Tool Construction Association imeni the 50th Anniversary of the USSR became the head enterprise of the Ivanovo-Sofia International Scientific Production Association, doing work in accordance with the Comprehensive Program of Scientific-Technical Progress of CEMA Nations for the Period up to the Year 2000.

In 1986-1990 there is to be an increase by roughly 60 percent over the 11th 5-Year Plan in the production of competitive multiple-operation machine tools, for which there is a nearly unlimited customer demand. Another goal is certification of all new equipment for only a higher category of quality. The shift index of the latest inventory is to be brought to 2.8 percent, and the usable effective operation of machine tools is to be raised to 92 percent.

The Moscow Plant of Transfer Machines imeni the 50th Anniversary of the USSR is among the leading machine tool construction enterprises. Over the past 25 years, goods produced by this plant have relieved about 30,000 workers in the national economy of the USSR.

Beginning with the Ninth 5-Year Plan, the plant has been preparing comprehensive long-range plans of economic and social development for every 5-year period. Each plan is an aggregate of measures aimed at maximum discovery and utilization of economic and social reserves of growth of production facilities, labor productivity and enhancement of the quality of goods.

For the 11th 5-Year Plan, the plant was to produce transfer machines for an entire technological cycle of machining items without the use of manual labor, starting with a blank and ending with packaging of the finished item. There was to be an increase in the quality, reliability and accuracy of equipment, resulting in an elevation of productivity by 20-30 percent. It was planned to upgrade the transfer lines and machines produced, to reduce the margins for blanks, increase cutting speeds and feeds, and also introduce systems for automatic optimization of machining cycles, and computers, networking them with computer-aided production management system of shops and consumer plants.

All this was supposed to enable, and did actually enable, release of more than 10,000 workers in the national economy with a savings of 23.5 million rubles.

And what was done to accomplish these goals? Let us recall that the plant produces transfer machines and machine tools in small lots and series in a one-at-a-time process. This gets very complicated, as a new item has to be mastered each time. It was decided to appreciably increase the degree of standardization of goods produced by making sets of optimum lots of machine tools of different models. For example, in designing internal and cylindrical grinders, a modular principle is used that enables production of more than 100 modifications of 15 base models.

The production of precision machine tools and transfer machines corresponding to the latest advances in science and engineering presumes constant upgrading of production technology. In this area, provisions have been made for further specialization, mechanization and automation of production, and replacement of obsolescent equipment. For example, it has been calculated that replacement of 200 units of obsolescent metal-cutting equipment will save 25,000 rubles, and the use of new kinds of equipment will save 30,000 rubles.

To ensure mobility of production, fewer machine tools with manual control are being purchased. NC machine tools are concentrated in one subdivision: the technological department of programmed machining. This has raised the efficiency of their use, and has enabled production of the most complicated goods under conditions of a shortage of skilled workers, while dramatically shortening production cycles. All the equipment not needed for carrying out the program has been sold to organizations where it can still be put to use. Fifty-one transfer lines were produced in 1985 alone.

The quota of the 11th 5-Year Plan with respect to production volume was met in June 1985. The pace that had been planned for the 11th 5-Year Plan with respect to volume of salable goods was attained in March, and with respect to labor productivity, in April 1985. By the end of 1985, the plant had exceeded the 5-year production quota by 20.5 million rubles.

As we have already said, for some time our nation has produced an average of more than 200,000 machine tools annually. Making them has required some 200,000 metric tons of cast iron. Two-shift operation of these machine tools has required about 400,000 workers. There is a shortage of workers, and a large contingent of machines has been idle. The experience of the Ivanovo Machine Tool Production Association imeni the 50th Anniversary of the USSR shows that rather than making 200,000 machine tools a year, let us say, 75,000 could be produced, but such as would compensate for the difference in productivity. The result would be an enormous savings of metal and human resources.

Ferrous metallurgy: supplier of structural materials. Ambitious goals in reconstruction and retooling of enterprises have been set for ferrous metallurgy—one of the base industries of the national economy. Both the dynamic development of machine building, construction and transportation, and the economic potential of the national economy as a whole hinge on the scale and pace of development of this sector.

Let us give a few figures. Over the last 16 years the volume of production of finished rolled goods in the USSR has risen by a factor of 1.3, while the output of economic kinds of metal goods has increased to a much greater degree: low-alloy rolled steel by a factor of 1.9, with hardening heat treatment by a factor of 2.3, bent structural shapes by a factor of 5.2, cold-rolled plate by a factor of 1.9, and coated sheet steel by a factor of 2.

To meet the demands of the national economy for new effective kinds of metal goods over this period, about 1,200 new grades of steel have been assimilated, along with 1,900 new high-quality hot-rolled, cold-formed, and steel structural shapes.

Progressive technological methods have been developed for assimilating the production of new economic kinds of metal goods: high-strength steels, low-alloyed and micro-alloyed with niobium and rare-earth elements, rolled goods with differentiated level of strength properties, rolled goods with guaranteed strength, and so on.

The improvement in quality and enlargement of the variety of rolled goods, and advancement of steel melting technology have saved more than 40 million metric tons of metal in the national economy in 1970-1984.

Despite the results that have been achieved in the development of ferrous metallurgy, the needs of the national economy for metal goods, both with respect to production volumes, and with respect to variety and quality, are not being completely met. The industry is lagging in expansion of the production of the most progressive kinds of rolled structural shapes, intermediate items, pipes, and metalware. Individual kinds of ferrous metals produced on obsolescent equipment do not meet modern requirements for quality and variety. Because of problems with the assortment of rolled stock

and the inadequate volume of production of effective kinds of goods, as well as the increased structural metal intensiveness of machines, equipment, and structures, and the low coefficient of utilization of metal, there is an overconsumption of 15-17 million metric tons of rolled goods each year.

The main reasons for the situation that has arisen with regard to metal are the imperfect structure and in some cases the low technological level of steel production, and the considerable volume of obsolescent equipment in service in the industry. Retirement of obsolescent capital in the steel industry over the last three 5-year periods has averaged about 1 percent instead of the required 3-4 percent, which has precluded the timely replacement of equipment, led to heavy loading (96-98 percent), and limited the possibilities for extensive assimilation of new and progressive kinds of metal goods and improvement of quality. More than 33 percent of the iron, 60 percent of the steel, and about 60 percent of the hot-rolled stock is being produced on equipment with an extended service life.

A considerable qualitative change is planned in the immediate future for ferrous metallurgy. This applies principally to the structure and quality of metal goods, wider variety and increased production of the most economic kinds of goods. In 1990, 116-119 million metric tons of finished rolled goods are to be produced without increasing the production of pig iron, and with a considerable reduction of coke consumption.

The end of the 5-year period should see assimilation of at least 500 new structural shapes, expanded production of pipes of petroleum grade, gas-line and other kinds of pipes with factory anticorrosion protection, and metalware. Production of metal powder is to be more than doubled. There will be an expansion of the industrial assimilation of technology for direct production of iron and fundamentally new metallic materials.

Where will the reconstruction and retooling of the industry start? Naturally, in the production facilities built during and before the first 5-year plans: the Magnitogorsk and Kuznetsk Integrated Steel Plants, low-capacity steel plants in the Urals; reconstruction and retooling will continue on metallurgical enterprises in the Ukraine, and reconstruction will be started at Rustavi Steel Plant.

A major role in raising the technical level of ferrous metallurgy is played by reconstruction and retooling of steel melting production with a radical change in the structure of steel melting in connection with the use of oxygen converter and electric steel melting methods of producing steel in combination with facilities for processing steel away from the furnace and continuous casting of blanks.

By 1990, oxygen converter and electric steel melting will increase by a factor of 1.3-1.4, and continuous steel casting will at least double. In this process, there will be extensive introduction of new technology for melting steel in converters with combined lancing, technology for deep oxygen lancing of the bath in large-tonnage open-hearth furnaces, and so on. This will enable more complete utilization of the available scrap metal resources in the nation.

The principal direction of technical progress in rolling production will be the development of new processes and equipment based on principles of continuous rolling and combining a large number of operations in the process line, with large-scale mechanization and automation of all technological processes. Introduction of new rolling technology calls for installing rigid rolling stands, heat treating the metal in the line, and in standalone units, controllable rolling, and other advances in rolling production technology.

With consideration of the requirements of users, production of rolled stock with high quality indices will be organized on massive scales: merchant shapes and rolled plate with rigid tolerances on dimensions, normalized structure, and mechanical properties within set limits, rolled plate with high flatness indices, cold-rolled sheet for intricate drawing, steel for cold heading, allowing a high level of upsetting, and so on.

The general direction of scientific-technical progress in ferrous metallurgy is extensive introduction of progressive technological processes and highly productive equipment, and reduction of heavy and labor intensive operations based on comprehensive automation and mechanization of production.

In 1985, localized automation systems in enterprises of the sector numbered more than 13,000, computer-aided process control systems—about 260, computer-aided production management systems—48, and computing centers—63. Roughly 60 percent of the computer equipment operating in the sector is used for controlling technological processes, and 40 percent—for production management, and also for engineering and economic calculations.

Two sector-wide computer-aided management systems are in operation: OASU Chermet on the scale of the USSR Ministry of Ferrous Metallurgy, where about 520 management jobs are now being handled, and OASU Ukrchermet on the scale of the UkSSR Ministry of Ferrous Metallurgy, where about 500 management jobs are being handled. During the 11th 5-Year Plan, there have been about 6,000 localized automation systems, 130 computer-aided process control systems, and 14 computer-aided production management systems introduced in ferrous metallurgy. The number of computers has doubled.

More than 300 operating aggregates and facilities of ferrous metallurgy have been equipped with specialized instruments, devices, and systems for automation. Six hundred industrial robots and automatic manipulators have been introduced.

The overall level of automation of major facilities during the 11th 5-Year Plan has reached 71 percent. The introduction of automation facilities and systems on many installations has brought a 2-5 percent increase in the productivity of metallurgical lines as a result of stabilizing operating conditions, a 2-3 percent reduction in the expenditure of raw materials, fuel, energy per unit of finished goods, and increased labor productivity. The mean annual economic effect has exceeded 110 million rubles, and 7,700 workers have been released for use on other jobs.

During the 12th 5-Year Plan, 170 computer-aided process control systems are to be developed and introduced on newly constructed, rebuilt, and existing enterprises and facilities, 18 computer-aided production management systems on the plant and department management level, and 750 industrial robots and robot systems are to be introduced.

The anticipated economic effect in the current 5-year period as a result of automating major technological processes combined with computer-aided production management will be 680 million rubles. Automation will release more than 10,000 workers, mainly in mining, metalwares, and refractories, and also on sections for inspecting, grading, and finishing rolled goods, where the introduction of automated equipment will liberate personnel from manual labor; labor productivity will be increased by 2.6 percent, leading to an additional conditional release of another 24,000 workers, and working conditions will be improved and lightened for 12,000 workers.

In addition to solving technical and economic problems, production automation will also improve working conditions, raise the level of safety, and make the environment healthier.

Advantages of retooling and reconstruction in ferrous metallurgy over the construction of new facilities, such as more rapid attainment of planned technical-economic indicators, faster and higher return on capital investments and the like, and the encouraging experience in the reconstruction of existing facilities that has been accumulated in the sector (repair of blast furnaces with an increase in their volume, resetting coke-oven batteries with an increase in the capacity of chambers, upgrading oxygen converter shops by replacing small-capacity converters with more productive ones), and also experience in retooling of old plants, show that the course toward acceleration of scientific-technical progress by introduction of the latest technological processes and equipment not only in new construction, but also in reconstruction, enables a radical increase in labor productivity in the sector, and in the quality of metal goods.

Heavy load, less down time. More effective use of machines and equipment, an increase in the output of goods from each unit of equipment, from each machine tool, for example from each square meter of production area, are important factors for intensifying production. The most immediate reserve here is an increase in equipment loading, a reduction of idle time. It has been computed that a mere one-kopek increase in the output of industrial goods from each ruble of value of fixed productive capital would increase the gross value of production by 8 billion rubles.

In recent years, the average cost of a metal-cutting machine tool has been continually increasing. In 1960 it was 2,500 rubles, in 1970—4,600 rubles, and in 1985 it was more than 10,100 rubles. The NC machine tool is much more expensive than a universal machine tool. It costs about 55,000 rubles on average. The productivity of such a machine tool is roughly double that of a conventional universal tool. For a 10-year average service life of either machine, direct expenditures on producing a single item on the NC machine tool are about 4.5 rubles, as compared with 3.6 rubles for the universal machine.

Economic justification of the use of robots and flexible computerized manufacturing systems requires considerable work on radical reorganization of plants, increased production specialization, loading technological equipment, and personnel training. According to data of Ivanovo Machine Tool Association, with two-shift loading, flexible computerized manufacturing systems are used about 28 percent of the annual calendar machine time. The reason for this is the inevitable losses involved in reconfiguring and repairing equipment, changing tools and fittings, and also organizational losses. On a three-shift schedule of equipment operation, the useful time increases to 47 percent, and it is only with a continuous round-the-clock schedule that it may approach 80 percent.

Similar results have been found in a number of Japanese plants that are introducing robots. The conclusion is clear: When it installs robots or flexible computerized manufacturing systems, an enterprise must take a careful look at production organization. It is only in this way that conditions are brought about for economically sound utilization of this very necessary, but also very costly equipment.

In recent years in industry, the coefficient of utilization of equipment has been 1.45, and the shift index has been continually declining for many years. The main reason for this is that while industry has been constantly saturated with equipment, most machine building enterprises, for example, have been operating on one shift.

The main directions of economic and social development of the national economy call for bringing the shift index of equipment to 1.6-1.8 by 1990, which includes bringing this index to 1.9 for equipment with programmed control and automatic transfer lines, and to 2-2.5 for flexible manufacturing modules and systems. We know how this is to be done. Work must be organized in two or three shifts with elimination of equipment down time, improvement of material and technical support of workstations, repair, and reinforcement of discipline. The elimination of old machine tools enables more efficient utilization of new and highly productive equipment, organized so that it does not stand idle. Just as important is the clearing of production space, and reduction of repair expenses. According to the calculations of specialists, the removal of surplus and obsolescent equipment from machine building shops can save roughly 1 billion rubles per year in repairs alone. More than 100 million m^2 of production area will be cleared, obviating the need for new buildings at a cost of 20 billion rubles.

Improvement of the use of equipment during a shift yields an effect that is just as great. Here there are also appreciable reserves: the fraction of shift-long down time of metalworking equipment in main production is 8-13 percent, and of part-shift down time—12-26 percent. The main cause is disrepair and unplanned repair of equipment, lack of correspondence between the machine tool inventory and the production program, and so on. The most effective way to reduce down time due to disrepair of equipment is to produce machines that require minimum expenditures on repair and maintenance during service. Future plans for a considerable increase in the technical level of machines and equipment include steps for extending the period between repairs, improving the reliability of equipment, and increasing the time of failsafe operation. Conducive to improvement of these parameters is company repair and service by the manufacturing staff, who will compare the repair expenses with expenditures on improving the quality and reliability of the equipment. Comprehensive measures will be taken to develop company repair of machines and equipment in the 12th 5-Year Plan.

Also conducive to raising the quality and reducing the cost of repair work is centralization within the confines of the enterprise. Experience of leading collectives, e.g., the AvtoVAZ collective, shows that in comparison with repair done by shop services, there is a 15-20 percent increase in labor productivity with centralization, a reduction in prime cost, and an improvement in the quality of repair. Development of preventive maintenance following completion of a work shift (at night, on weekends, during vacation, etc.) has a positive impact on reducing down time of equipment.

Yet another reserve of economy is putting uninstalled equipment into service. In every industry the cost of such equipment runs into the millions of rubles. Not only is it giving no return, but it is taking up production space, and getting obsolescent, and is damaged because of poor storage. Putting uninstalled equipment into operation will appreciably increase the production of goods from each square meter of production area, and will increase capital productivity.

The effectiveness of using fixed productive capital depends in large measure on timely attainment of technical-economic design indicators of new production capacities that have been put into service. According to data of the Central Statistical Administration of the USSR, of 1,852 departments, enterprises, and other facilities introduced and rebuilt during the 11th 5-Year Plan, 1,237 are being incompletely utilized, and are being assimilated with violation of normative time schedules. In these facilities, the actual production volume has been 67 percent of the actual production capabilities; the production of goods has been 9.5 billion rubles less than the planned level. The delay in assimilation of new and rebuilt enterprises and in attainment of their rated capabilities results in yearly losses of 20 billion rubles in the national economy. The reserve for the economy is great.

Technology: a revolutionary element. The last two decades have witnessed the advent of a new stage in the current scientific-technical revolution due mainly to the burgeoning development of microelectronics, information science, robotics, bionics, laser technology, and nuclear power. It is a stage of radical changes in production technology, giving rise to the term "technological revolution." It is the results of fundamental research that bring modern technology to revolutionary changes. Based on such research and discoveries, machines have been developed that operate on completely new principles, including turbojet and jet engines, ground-effect machines, hydrofoils, mini- and super-computers, NC machine tools and machining centers, laser equipment, electrophysical and electrochemical machine tools. Progressive technological processes have been developed that ensure high production efficiency. These include electroslag casting, continuous teeming of steel, extrusion production of items, high-efficiency technological processes for producing new plastics, composites and semiconductor materials, thin films, single crystals and polycrystals.

A distinguishing feature of technical progress in our time is that it is occasioned not by individual advances in science, but by massive introduction of research results in an entire area of engineering and technology, by the intimate interaction and mutual impact of science and industry. A high level of experimental research and industrial development speeds up processes of practical utilization of advances in science, shortens the time between scientific discoveries and their industrial assimilation.

The considerable economic value of technical progress is confirmed by a body of specific facts, including the latest data. A number of actual examples could be named in

which a change of technologies, other things being equal, multiplies labor productivity, even by a factor of tens, reduces capital expenditures (as compared with the proliferation of conventional technologies), reduces the material intensiveness of goods, improves their quality, and dramatically improves working conditions. Let us mention in particular such technologies well known to the readers of our publications as the method of direct reduction of iron from ore, powder metallurgy, working metals by various methods of plastic deformation, the use of new construction materials, and so on.

One of the major goals of raising production efficiency is replacement of technological processes based on metal cutting with more economic shaping methods. The industrial use of electrophysical and electrochemical processes, hydro-, gas- and light-extrusion, the use of electromagnetic fields, laser machining, impulse-explosive methods, ultra-high pressures and the like enable fabrication of machine components without removing a chip, machining blanks of ultrahard and refractory metals that are not amenable to machining by other methods. This brings a considerable increase in labor productivity, enhances the physicomechanical and other properties of items, and saves metal.

Studies of the properties and areas of application of lasers and masers have solved crucial problems in the development and introduction of new equipment and technology. For example, a laser beam can be used to make holes of very small diameters and comparatively great depth in components of churlish materials, "punch" holes in watch jewels, cut materials, weld metals, for noncontact checking of the geometric dimensions of parts and their surface roughness, for automatic balancing of rotating parts, to determine the contamination of liquids and gases, and for many other operations. The development of high-power lasers will considerably extend their technological application.

In each of the machine building ministries there is a set of measures for expanding the use of laser technology. In particular, during the 12th 5-Year Plan, industrial sections with laser technology for machining parts are to be set up in BelAZ, KrAZ, and GPZ-2 of the Ministry of the Automotive Industry, at the Odessa and Sterlitamak plants of the Ministry of the Machine Tool Industry, and also in some enterprises of the ministries of power machinery, instrument making, and heavy machinery.

The change in composition and mechanical properties of tool materials is one of the main factors influencing the increase in productivity of metalworking equipment and the creation of new technological systems. For example, the replacement of existing abrasives with cubic boron nitride materials even now enables machining of metals at a temperature of more than 1500°C. The use of synthetic diamonds in abrasive tools for machining ultrahard parts increases tool life by a factor of 5-6 and quadruples productivity. Diamond tools are being used not only in machine building, but also for working stone, concrete, glass, and in drill rigs.

More than 7,000 rotary and rotary-conveyer lines are to be made during the 12th 5-Year Plan. Their use will raise labor productivity by a factor of 5-10, reduce the requirement of production areas by a factor of 2-3, and reduce the volume of transport operations by a factor of 15.

President of the USSR Academy of Sciences G.I. Marchuk has stressed the special importance of intensive development of the national economy in our time. In one of his papers, he notes: "The period of burgeoning development of the production system is coming to a close. The main task now is to increase the return of fixed productive capital. Intensive economy suggests that this be done primarily by continued use of fundamental scientific ideas, which should be realized via the latest technology in the form of machines, equipment and instruments of a higher technical level. It is this chain that will most rapidly and effectively pave the way to new engineering developments with the greatest benefit to society... Technology is a crucial element of creation that stands at the juncture of science and industry and joins them into a unified process."

6610/6091

UDC 338.621

Increasing Efficiency of Machine Building Production Under Conditions of Restructuring Economic Mechanism

18610014a Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 2, Apr-May-Jun 88 pp 1-3

[Article by V. S. Kovalenko, doctor of technical sciences, dean of the chemical machine building faculty at Kiev Polytechnic Institute]

[Text] The main directions of the economic and social development of the SSSR between 1986 and 1990 and for the Period up until the year 2000 stipulates the leading development of machine building as the sector determining scientific-technical progress. Thus, if a 21 to 24 percent increase in production has been slated for the other industrial sectors, in the machine building sector this indicator has been set at between 40 and 45 percent for the five-year-plan. This complicated task can be accomplished by intensifying machine building production.

Between 1965 and 1980, the country's machine tool park increased 2.5-fold, surpassing the machine tool park of the United States, Japan, and the FRG together. The sector's existing capabilities are not, however, being fully utilized, largely because of an inadequate work force. The transition from a two- to a three-shift operating mode has made it possible to increase the efficiency with

which equipment is used. However, a fundamental solution of this problem is only possible by creating high-productivity equipment based on the latest technologies to replace the existing machine tool park. Machine tools with numerical programmed control, machining centers, rotary and rotary-conveyer lines, and computer-integrated manufacturing complexes and systems must be used on a wider scale.

Reducing breakdowns and transport losses when products are manufactured also increases the efficiency with which equipment is used. Based on data from American researchers, only 7 percent of the time of the production cycle required to produce a component is spent directly on the machining process. Most of the time is wasted on transporting components and storing them between operations. To have the duration of the production cycle maximally approximate the time directly spent on manufacturing a component, subassembly, or entire machine, it is advisable to combine the machining of products with their transfer between operations on rotary or rotary-conveyer lines.

The labor intensity of manufacturing products can also be reduced by introducing fundamentally new technologies and improving traditional machining methods. Thus, according to researchers' forecasts, by the end of the 21st century the cutting speed in traditional machining operations will increase to 30,000 m/s, with the surface roughness not exceeding 0.01 microns.

The requirements for the precision with which components are manufactured are increasing. Ultraprecise technology, or nanotechnology, in which the deviations in components' sizes are within the range of tens of nanometers, is currently being created.

A significant increase in the precision with which products are manufactured and an increase in the efficiency of removing material when components are shaped, especially in the case of components made of new, difficult-to-machine building materials, are possible by the wide-scale use of fundamentally new technologies, including electron beam, plasma, laser, electroerosion, and electrochemical technologies.

A significant effect is obtained when the advantages of different machining methods are combined in one technology. Combined machining methods—including electroerosion-chemical, ultrasonic, electrochemical, electrolaser—are being successfully developed. Traditional machining methods including magnetic-abrasive and plasma- and laser-mechanical methods are being improved.

The highest type of modern machine building production is automated production based on the use of flexible manufacturing systems. These systems make it possible to manufacture products in a highly productive manner and to quickly retool for the production of new products. However, flexible manufacturing systems have serious shortcomings: such systems are geared toward mechanical machining methods, they have a limited number of tools simultaneously participating in an operation, and their tools and subassemblies are not sufficiently reliable.

Providing full automation and effecting the transition to unmanned production technologies requires a 10-fold increase in the reliability of equipment and machinery. The interbranch scientific-technical complex Machine Reliability, which has been created in this country, has been called upon to solve this problem.

The use of fundamentally new methods of ensuring reliability (forecasting failures, creating models of machines' operation, introducing new methods of calculating reliability characteristics, improving the designs of components and machines) is very important. Also important is the wide-scale development of hardening technology, especially the application of coatings, which increases products' operating properties and significantly reduces the consumption of materials that are expensive and in short supply. This resource is not being adequately used at the present time. Thus, according to data from the All-Union Tools Scientific Research Institute (Moscow), in the USSR the relative share of hard-alloy tools with a coating amounted to 37 percent in 1980 and will reach 47 percent in 1990, whereas abroad virtually all hard-alloy tools are manufactured with a wear-resistant coating. In the Ministry of Machine Tool Building systems only 20 percent of tools made of high-speed cutting steel are currently manufactured with coatings. Such coatings increase their durability 2- to 2.5-fold.

Under conditions in which the centralized supply of hardening tools to enterprises is inadequate, hardening technologies and respective equipment must be introduced on a wider scale.

Besides improved methods of thermal, cryogenic, and chemicothermal treatment, the last few years have seen the successful use of hardening technologies based on the plastic deformation of material—smoothing by means of rollers and balls, explosive hardening, shot-blasting, and ultrasonic hardening. Methods based on electrical physicochemical effects have appeared: plasma stream hardening, electron beam hardening, electrospark alloying, ion-plasma coating, electrochemical and electrophoretic hardening, epilamination [epilaminirovaniye], application of detonation coatings, laser surface treatment, local alloying, coating, surfacing, cladding, shock hardening, etc. These methods make it possible to increase a tool's wear resistance two- to fourfold or (in a number of cases) more.

Positive experience in launching new technologies has been accrued at the Kiev Production Association imeni S.P. Korolev. At the association, production processes have been tested under production conditions, the areas

in which use of the new technologies is feasible have been identified, and comparative evaluations of the different hardening technologies have been obtained.

The Bolshevik Production Association (Kiev) and the laser technology laboratory at Kiev Polytechnic Institute have jointly created the sector's first laser technology section where the latest scientific ideas in the field of increasing the durability of machinery and components are being verified. The best of these technologies are being implemented.

Progressive hardening methods are also being introduced in the Kiev Machine Tool Building Production Association, the Plant imeni V. A. Malyshev Production Association (Kharkov), the Arsenal Plant imeni V. I. Lenin Production Association, and a number of other associations and enterprises throughout the republic. Working in conjunction with the Electrowelding Institute imeni Ye. O. Paton, the Problems of Material Science Institute, and the Ultrahard Materials Institute of the UkSSR Academy of Sciences, the Kiev and Kharkov Polytechnic Institutes, the Kiev Automotive and Road Institute, and the Uzhgorod State University, the aforementioned associations and enterprises are developing and introducing new methods that not only make it possible to increase labor productivity, reduce the power and material intensity of manufacturing products, and increase products' reliability and other operating indicators but that also make it possible to achieve significant improvements in labor productivity.

The absence of the respective specialists is a serious obstacle standing in the way of the wide-scale use of new, highly effective processes of machining materials. Some higher educational institutions have, at their own initiative, begun training specialists in this field (the Moscow Higher Technical School imeni N. E. Bauman and the Kiev and Leningrad Polytechnic Institutes). The SSSR Ministry of Education has established a new specialty, Machines and the Technology of High-Efficiency Machining Processes (no. 1207), in which higher educational institutions will train highly qualified specialists for the machine building complex.

While attempting to solve the problem of increasing production efficiency, the directors of several enterprises have taken the route of achieving momentary results and have proceeded without foresight. They are cutting expenditures for scientific developments to update obsolete and create new equipment and to develop high-productivity production processes.

Under the conditions of the creation of a new economic mechanism in machine building, the development of cost accounting, and self-finance and self-support, the efficiency of enterprises' activities will be largely dependent on how quickly they can master the latest engineering and technology, thereby emerging victorious in their competition with related enterprises.

12794

UDC 621:658.001.2

Increasing Efficiency of Machining

18610014b Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 2, Apr-May-Jun 88 pp 7-9

[Article by Ye. A. Beltyukov, candidate of technical sciences, N. N. Pavlova, and S. S. Mironchenko]

[Text] The main way to increase the efficiency of production based on machining is to optimize its technical level by introducing progressive engineering and technology and making maximum use of equipment's operating parameters as well as by improving the manner in which the production process is organized.

At the Odessa Precision Machine Tools Plant imeni the 25th CPSU Congress, machining production is being intensified by certifying workstations. Workstations' technical and organizational level as well as their actual production capabilities are being determined during the certification. These indicators are being used to develop measures to remove obsolete equipment from the production process and accelerate the pace at which equipment is updated. As a result of the certification, 49 machine tools were removed from operation at the plant. The certification made it possible to identify the workstations and production sections that conform to the modern technical level and to discover sections in which it is economically feasible to use robotized production complexes, machining centers, and machine tools with numerical programmed control. The specified progressive production systems have been put into production.

The task of intensifying production may be accomplished successfully by standardizing and unifying components and their elements, which creates the prerequisites for organizing specialized shops and sections to manufacture them.

At the plant, components were classified from the standpoint of their main design and production indicators. As a result, the entire inventory of components used in machining production was divided into five main groups, each of which was in turn subdivided into three subgroups. The following technical and economic indicators lay at the basis of the classification: overall dimensions, shape, material being machined, number of sides being machined, precision of machining, number of operations, labor intensity of manufacturing, component cost, and type and models of the equipment used.

The level of production organization was analyzed for each group, and the main factors predetermining this level were identified.

The small-series nature of modern machine tool production when traditional organization methods are used results in significant economic losses. It is therefore important to switch over to using progressive forms characteristic of the organization of series and mass production. One of the prerequisites for this is the high degree of flexibility of modern production machine systems, which may operate in a corrective adjustment mode when a transition to manufacturing another product is made.

Under such conditions, well-founded calendar plan norms should be the criteria on which the organization of the production process is based. The most important thing when these norms are determined is to make an allowance for organizational factors, above all, to consider the needs of subsequent production stages when formulating and regulating the sequence of previous production programs.

Attention was paid to workstations' coefficient of specialization (the ratio of the total number of operations performed in a shop or section to the number of workstations). Reducing the numerical value of this coefficient facilitates an improvement in the utilization of equipment and the work force as well as an increase in the capital-output ratio and in labor productivity.

At the plant a great deal of attention is being paid to ensuring that the sizes of production assignments are multiples of the size of monthly programs, which creates the prerequisites for organizing rhythmic production.

The load on equipment, with an allowance for its cost, age characteristics, and the complete use of its technical parameters, is the determinant organizational factor. In the case of flexible systems and robotized complexes, production assignments must ensure their continuous operation. For machining centers, machine tools with numerical programmed control, and other types of expensive equipment, production assignments must ensure operation for 2 to 2.5 shifts.

In the case where expensive, high-efficiency equipment is used, establishing rational lots of components produced on the equipment acquires special importance. Calculations performed at the plant made it possible to determine five lot sizes that served as the basis for organizing the production of machine tool products. Depending on their complexity, labor intensity, number of operations, overall dimensions, precision, and other technical-economic parameters, components are manufactured in lots equal to monthly, bimonthly, quarterly, semi-annual, and annual quotas. This made it possible to change the structure of the list of components being machined. Thus, the number of different components that were in production at the same time was reduced from 2,250 to 934, i.e., 2.41-fold.

The improvement in the organization of the launching of components into production resulted in an improvement in the use of equipment and a significant reduction in the duration of the production cycle. Thus, after the introduction of stable lots that were 2 to 2.4 times their former size, the total amount of time required to perform setup and clear operations was reduced 2.5-fold, which resulted in a wage savings of 17,900 rubles.

The duration of the production cycle required to produce the most complex casing components was reduced an average of 2- to 2.5-fold. For example, the machining cycle for cast blanks was reduced 2.1- to 3.2-fold, that for rods was reduced between 2.7- to 4.5-fold, and that for flat components was cut in half. As a result of the intensification in production, the average norm for unfinished production was reduced from 47,100 to 30,600 norm-hours, i.e., more than 1.5-fold.

The freeing of more than 5 to 7 percent of the production areas, the freeing of 4.5 to 5 percent of low-productivity universal equipment, an increase in the shift coefficient from 1.66 to 1.81, and the conditional release of 6 to 8 percent of basic workers are no less important economic results of the improvement in running planning at the plant.

The improvement in the organization of the production of machine tool components in the plant's machine shops has made it possible to obtain an annual savings of more than 60,000 rubles, virtually without any additional expenditures of physical and labor resources.

12794

UDC 658.588.8:65.014076

Regional-Branch Development of Repair Industry

18610014c Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 2 Apr-May-Jun 88 pp 9-11

[Article by V. F. Shudra, candidate of economic sciences]

[Text] As an interbranch industry, the repair industry is distinguished by its tendency toward territorial forms of organization. The branch approach to the development of infrastructure capabilities, including repair capabilities, does not permit a balance between base industries and the industries servicing them.

The lack of balance between the capabilities of the repair complex and a region's program of industrial development is one of the main reasons for the low efficiency with which equipment is used in the basic and repair industries alike. The importance of having the basic enterprises in a particular region and the infrastructure enterprises that service them develop in proportion to

one another has been underestimated. Because of this underestimation and because of the resources allocated for the development of basic production, tens of thousands of low-efficiency repair subdivisions have been created within the framework of many ministries and departments that use technology.

Thus, only 35.7 percent of the total number of metal-cutting machine tools in the UkSSR's national economy are located in repair shops.

The absence of centralized management and the lack of departmental coordination of repair service has resulted in a situation where only 20 percent of the total number of the country's repair services are specialized and only 4 percent are optimal from the standpoint of their capabilities. As a result, expenditures to repair technology that is currently in use are constantly increasing.

The scales of the currently operational equipment park, its ever-increasing complexity, and the wide-scale dissemination of new production systems based on new-generation technologies do not permit a solution to the problem of radically increasing the efficiency of the repair service industry within the framework of individual enterprises or even branches of industry. For this reason, the organizational subdivision and formulation of a repair complex that makes it possible to effect a transition from branch to regional-branch planning and management is imperative.

A unified centralized approach to planning within the framework of the repair complex must become an important condition of implementing long-term interbranch programs for its development. This approach should create the prerequisites for optimizing the structures and proportions of specialized enterprises for the major overhaul of equipment designated for interbranch use and the centralized production of spare parts, branch repair plants, and in-plant repair facilities.

By designating special organs to coordinate the interaction of the numerous ministries that manufacture and use equipment, concentrate resources on creating repair capabilities, and monitor the use of physical-technical, labor, and financial resources in repair facilities, it will be possible to provide the necessary coordination and sequence of operations and flexible reallocation of resources between individual units.

The territórial-branch approach to formulating a repair infrastructure predetermines that an allowance be made for the economic effect resulting from the functioning of the approach. The most complicated economic effect to consider is that realized by the service user (an indirect effect), but it is the principal effect and the one necessitating that infrastructure industries be developed.

The indirect effect is substantially greater than the direct effect obtained in the infrastructure branches. Consolidated calculations have shown that creating a highly developed repair infrastructure in the territory of the UkSSR (which requires capital investments estimated at between 650 and 700 million rubles) will make it possible to obtain an annual savings of 155 to 160 million rubles by reducing running expenses on repair services in the branches using the repair complex and an annual savings of 24 to 50 million rubles directly in the repair service sphere. This savings will come from an increase in labor productivity and from the freeing-up of workers. An effect of 76 to 78 percent will thus be realized within the bounds of the repair infrastructure, and a 22 to 24 percent effect will be achieved directly in the republic's repair industry.

One distinguishing feature of territorial repair complexes is the great numbers of users of their services. They must therefore be created in stages by concentrating capital investments allocated by individual service users in the territorial interbranch administrative organ. The share to be contributed by the participating ministries and departments should be determined in accordance with the size of the specific effect each will derive from the development of the repair infrastructure (rather than by the size of the repair fund). This will put enterprises located in different parts of a region and that thus have different transport costs and enterprises whose equipment has different degrees of physical wear on an equal basis. This step will also make it possible to make an allowance for the effect derived from reallocating volumes of repair work between repair services located in the same or in different plants or branches.

The total effect $\Delta\Pi$ from creating a repair infrastructure is calculated as the sum of the effects obtained by individual users as a result of a reduction in the required production expenses per unit of finished product.

$\Delta\Pi = \sum_{i=1}^{n} \sum_{j=1}^{T} \Pi_{ij} (З_{pij} - З_{cpij})$, where Πij is the product output at the i-th enterprise of the specified region in the j-th year after the industry's repair service system has been improved (in the respective measurement units); $З_{pij}$ and $З_{cpij}$ are the respective costs of a unit of product at the i-th enterprise in the j-th year before and and after the industry's repair service system has been improved; n is the number of enterprises participating in the creation of the regional repair service; and T is the calculation period (in years).

The need to obtain the maximal effect on the national economy while making the least possible amount of expenditures requires optimizing the proportions of production and infrastructural capital investments and, consequently, assumes taking a national economy approach to formulating the repair complex. The subsequent improvement in the repair industry at the level of the individual branches of the national economy thanks to development in this area is extensive. What is needed is a fundamental change in the very approach to the problem of providing repair and technical support to

labor by creating interbranch complexes within the framework of a unified system for the repair service industry.

12794

UDC 621.391:008.05

Structural Model of Flexible Machine System for Large-Series, Mass Production

18610014d Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 2 Apr-May-Jun 88 pp 16-18

[Article by T. A. Bagryantseva, Yu. I. Plyushchev, and V. V. Solodyak]

[Text] The Management of the National Economy Institute (Kiev) and one of the machine building enterprises jointly developed an organizational plan for a flexible machine system to manufacture consumer goods on mass production and large-series production scales. The creation of flexible machine systems to manufacture these types of products is currently receiving less attention than are small-series and custom production. This has to do with the fact that the fundamental tasks entailed in mass and large-series production are to obtain a high productivity and produce products at low cost. The best way to accomplish these tasks is to use rigid automated lines intended to manufacture one or two components over the course of the entire operating time. This is the case where the greatest productivity, a quick return on investments made in equipment, and a low cost of the product manufactured are all obtained.

The production of consumer goods does, however, entail a danger of quickly glutting the market. Moreover, the products' designs are modified. The volume of production is reduced over time, and the production capabilities that are freed up as a result must be used to produce other types of goods, i.e., a production system must possess production flexibility.

An analysis of the efficiency of manufacturing consumer goods on rigid continuous production lines used in large-series and mass production and in sections with retoolable machine tools that are configured according to types of operations showed that in rigid lines operations are implemented asynchronously. This in turn results in a substantial underloading of equipment and in an accumulation of significant stockpiles of intermediate products between operations. Designing a production system in the form of sections with retoolable equipment makes it possible to increase the intensity of machining, increase machine tools' utilization factors, and reduce the number of machine tools required. However, this type of organization of production requires a large number of pieces of program-retoolable equipment, and it makes developing a subsystem for operations and calendar planning and management significantly more complicated—especially during failures or when it is necessary to replace defective products. It also causes great difficulties in tying together the final machining cycle and the product output cycle.

A series-parallel design for flexible machine systems that is implemented in the form of group (multiobject) production lines to manufacture specified groups of components is the most effective design for mass production with discrete machining. Multiobject lines consist of production sections arranged in series in the order in which production operations are performed. All of the machine tools in a section perform an identical production function.

A group of components characterized by the common nature of their production process as well as by similar overall dimensions, geometric shapes, and types of material are produced on such a line. A group production process, i.e., a set of production operations in which the various components included in a group are machined along a common production route, is the basis for creating continuous production lines. When a group production route is used, several components may skip individual operations.

Such lines provide a closed cycle of machining components (component lots). The production process begins with blanks being fed from an automated warehouse to all workstations and ends with the transfer of finished products to a storage or assembly section. The line's sections are connected by between-operation storages (storage units to hold intermediate products) and an automated transport system.

Grouping components is the basis for designing group continuous production lines. When the structure of a machine shop is designed, grouping is done on the basis of the main criterion—the common nature of the production process. Components' geometric shape, type of material, and overall dimensions are additional data. An analysis of the list of components and production processes used in machining them resulted in the formation of 16 groups. The type of equipment and numbers of pieces of equipment in the sections of the line and on the line as a whole were selected on the basis of the group production process and the value of the total labor intensity according to types of operations for the component group machined on each line.

A block diagram and diagram of the machine shop's item flow were developed. The machining production system includes 16 group continuous production lines with local storage units between operations. The outer item flows for each line are the motion of the blanks from the storage unit holding the raw material to the first section of the line and then the feed of finished components from the final section of the line to the storage unit

servicing the assembly section. The inner item flow is the movement of the intermediate products from section to section along the line through the storage unit located between operations.

The high level of the storage unit's automation and mechanization and the presence of a stockpile of intermediate products make it possible to reduce the effect of the transport system and failures in the production system to a minimum. The main thing in managing this type of flexible machine system is to provide that volume of interoperation stockpiles at which operation of the line's sections is synchronized and at which the required number of each type of component arrives to be assembled, thus completing the finished product production cycle. Only in the case of a disruption in the functioning of the system or when a transition to the production of new products is being made is it necessary to reallocate capabilities.

The structural model of a group line makes it possible to develop an optimum functional plan, i.e., to compile that equipment operation schedule at which a specified set of components will be machined within a specified time at the maximum equipment load. When the schedule is compiled, the components are assigned to machine tools. This reduces the number of retoolings, the amount of program-retoolable equipment, and the volume of the stockpile between operations.

The following factors are responsible for the efficiency of the production system being designed:

—the new system has made it possible to use the equipment to its fullest capacity when each group of components is machined;—the equipment and production area required have been reduced by loading the equipment to full capacity as opposed to when rigid lines are used (about 600 units for rigid lines versus 393 units for group continuous production lines);

—the cost of the equipment park has been reduced compared with flexible automated sections on account of the use of machine tools with a different level of automation of production operations;

—group continuous production lines are highly productive because components are assigned to machine tools and because of the use of high-productivity automaton- or semi-automaton-type equipment; and

—production flexibility is achieved by grouping components and by using program-retoolable equipment, automated storage units between operations, and flexible transport equipment.

It is thus recommended that group continuous production lines be created to mass produce consumer goods. Such lines should include equipment with different levels of automation, storage units between operations, flexible transport equipment, and an automated control system.

The structural model of a flexible machine system to machine components that has been developed has been adopted as the basis for designing a shop.

12794

Development Trends, Status of Application of Progressive Forging Tool Designs in USSR

18610012a Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 6, Jun 88, p 7

[Article by L. N. Sokolov, V. N. Yefimov and V. I. Karnaukh]

[Text] The trends of development of an engineering item refer to the mechanisms characterizing the direction and tempo of development of the item as established by patent research. The direction of development, in turn, is characterized by the dynamics of development of the useful qualities of the item and the technical resources used in achieving them.

Most helpful to achieving the goals of analysis of the development trends is the nomenclature of useful qualities of the item, which can be found by analysis of the goals of the inventions pertaining to the item being modernized[1]. The goal of any invention is always to better certain qualities of the item in question. For this reason, by discovering all the goals of the inventions concerning the item under development, it is possible to compile an exhaustive list of its qualities.

In order to determine the development trends of forging tool design, an analysis was made of 112 inventor's certificates, published in the period from 1972 to 1986. The analysis revealed four useful qualities of forging tools (cf. figure), the betterment of which was the goal of the corresponding inventions. These include: the influence of the forging process on the quality of the forged pieces, the assurance of high productivity of the forging process, reduced energy consumption in deformation, and tool dependability. The quality index of the forged pieces includes such parameters as the amount of working of the metal structure per cross section of the blank, the degree of precision of the forging, and the lowering of the machining tolerances. All these parameters are related to the metal-to-product yield. An important factor influencing the rise in productivity is expanded technological capabilities or degree of universalization of the tools.

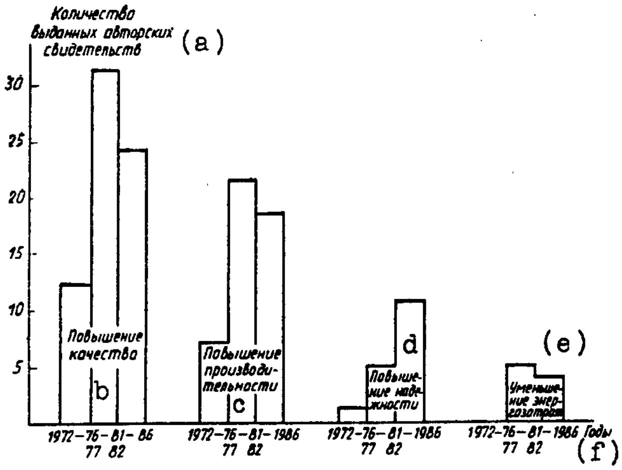

Diagram of Change in Useful Qualities of Forging Tools

Key:
a) Number of inventor's certificates issued
b) Enhanced quality
c) Enhanced productivity
d) Enhanced dependability
e) Reduced energy consumption
f) years

Analyzing the dynamics of change in the useful qualities of forging tools (figure), we discovered that the direction involving better quality of forging and increased productivity of the technological process underwent the most intense growth in the period of 1972 to 1986. In third place was tool dependability and in fourth place the lowering of energy consumption of the forging process. The number of inventor's certificates pertaining to all these parameters increased in 1977-1986.The invention activity in the period from 1972 to 1986 was concentrated primarily on improving the designs of die blocks as universal forging tools. Of 112 inventor's certificates examined, 61 inventions were aimed at improving flat, cutout, combination die blocks and die blocks with convex surface. We should mention in particular the tool assemblies, which are a group of several mechanisms or series of parts with complicated kinematics. The assemblies are designed to handle such tasks as increased productivity (e.g., by working the blanks on many sides), better quality of automatic regulation of the inclination of the die block in the forging process, less tool setup time.

In second place (as the focus of inventor activity) come ring rolling tools (21 certificates), followed by hole punching tools (13), swaging tools (9), tools for broaching hollow blanks (5), and disk forging tools (3 inventor's certificates).

We should point out the following characteristic trends of development of forging tool design. **For cutout and combination die blocks.** Better productivity and quality by having the working surface in the form of a combination of segments with different angle of inclination; better quality of forged work as a result of having the working surface with helical shape, for example, to afford maximum shear deformations; better productivity by die blocks with variable cutting angle during the forging process.

For ring rolling tools. Better quality and productivity by intensification of shear deformation with mandrels of noncircular shape, such as polyhedral; better quality by using mechanisms for continuous adjustment of the die block in the rolling process; expanded technological capabilities of universal forging equipment by using a rig for off-press rolling of large-sized rings and hoops.

Industrial adoption of the inventions is of great importance in establishing the actual status of the technology. According to the information of the All-Union Research Institute for Patent Information, 32 inventions have been placed in operation, constituting 30 percent of the inventor's certificates under discussion. The adoption of 12 inventions produced an economic impact of 1,363,060 rubles. The actual data concerning the implementation are shown in the table.

Tools	Number of inventions introduced with economic impact/Economic impact in rubles.
Forging die blocks	4/1,138,826
Broaching hollow blanks	2/167,836
Piercing	2/52,640
Ring rolling	3/3408
Disk forging	1/350

The number of inventions introduced with an economic impact over the existing processes is no more than 11 percent. The other inventions exist only in the form of descriptions in the inventor's certificates. It is therefore necessary to analyze the scientific-technical significance of each nonimplemented invention for its industrial utilization and assurance of major progress in forging technology.

Footnotes

1. Skornyakov, E. P., "Analysis of Development Trends of Technological Items in the Process of Patent Research," VOPROSY IZOBRETATELSTVA, No. 4, 1987.

12717

Progressive Forging Technological Processes (Scientific-Technical Conference)

18610012b Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 6, Jun 88, pp 8-9

[Article by I. S. Aliyev, V. N. Yefimov and V. G. Makshantsev]

[Text] A scientific-technical conference was held at Kramatorsk, organized by the Donetsk Oblast Administration of the VNTO Mechnical Engineers, the mechanical engineering section of the Donetsk Science Center of the Ukrainian SSR Academy of Sciences, the NIIPTmash, the Kramatorsk Industrial Institute, and the editors of the journal KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO. Taking part in the conference were specialists from the research and educational institutes, as well as representatives of the heavy and power generating machine enterprises holding a leading position in the field of forging technology for large pieces, the production associations Uralmash, the Novokramatrosk Machine Plant im. Lenin, Izhorsk Plant im. Zhdanov, Elektrostaltyazhmash, Zhdanovtyazhmash, Yuzhuralmash, Energomashspetstal Plant, and others.

The speakers noted the success in development of progressive forging technology processes at the production associations Uralmash, Izhorsk Plant im. Zhdanov, and other organizations, but at the same time they underscored the occasionally unsatisfactory situation regarding introduction of progressive designs of forging tools, expanded introduction of semi-continuous cast blanks for forging, new processing procedures (making use of thermal cycles) in production of forged pieces for energy generating machinery, use of stamped elements in forging technology processes, adoption of new technology procedures boosting the labor productivity, quality of metal, and forging regimes which lower the consumption of metal and energy.

In the opening remarks, professor N. M. Zolotukhin briefly described the status of work in the area of forging and urged the members of the conference to devote their efforts to the development and creation of fundamentally new technological processes and equipment enabling sharp improvement in labor productivity and quality.

The report of L. N. Sokolov and V. N. Yefimov was heard with great interest. On the basis of a patent analysis, they defined the development trends and status of introduction of progressive forging tool designs in the USSR.

The report of I. K. Marchenko, Yu. S. Kholodnyak, and N. L. Yarmak generalized the results of the industrial application at a pilot plant of forging regimes for semi-continuous cast blanks, using a special deforming tool.

Modernization of forging tools was also the subject of the work carried out by a group of engineers at the PO Yuzhuralmash, along with members of the UPI, under the leadership of V. N. Trubin. The report of V. S. Baakashvili, R. V. Lel and G. G. Giorgadze attempted to explain the physical phenomena of recovery of the metal plasticity resource in terms of the theory of heredity. Engineers V. S. Gumenyuk and S. A. Kavelin (VPI) presented theoretical-experimental investigations estabisihng the regions of compaction and loosening of forged pieces in the process of large-diameter pipe broaching. The report of V. M. Mikhalevich, S. M. Vaytsekhovich and V. A. Matveychuk (VPI, TsNIITmash) investigated the mechanisms of buildup of defects during multistaged deformation as an idealized diagram of the technological operation of broaching and proposed an algorithm for design of processes of nonmonotonic deformation to enable more effective impact of the mechanical working on the quality of the forged product.

A. A. Mishulin and V. M. Mikhalevich developed a model for buildup of defects during hot deformation and demonstrated that the proposed model reflects one of the fundamental features of metals—the restoration of plasticity in the intervals between loading.

The report of B. N. Shlyakman, L. P. Belovaya, V. A. Tyurin and V. A. Baranov (PO Izhorsk Plant im. Zhdanov, MISiS) was devoted to an investigation of deformability of metals at variable temperature. They established that the utmost plasticity of the materials under these conditions greatly exceeds the limit plasticity achieved by traditional methods, and the disparity increases with the temperature gradient of the testing.

The report of V. I. Dukhovchenko (KII) was devoted to the determination of large ingot heating regimes by the heat source method. The report of L. Kh. Dmitriyev and I. V. Dzyuina (PO Izhorsk Plant im. Zhdanov) was heard with interest. It examined the thermal processes in blanks during production of rotor forged products.

Many reports were devoted to development of new technological procedures and processes aimed at lowering the metal consumption and improving the quality of the forged pieces. These topics were discussed in the reports of G. M. Skudar, N. P. Portnyaga, V. V. Kubay (PO Novokramatorsk Machine Plant); I. B. Kucherenko, N. G. Tsygura, G. S. Grebenyuk (NIIPTmash), M. Ya. Belkin, I. S. Aliyev, V. N. Yefimov (KII). The report of L. N. Sokolov, V. V. Lapin and M. I. Yakovlev examined improved layouts for forging wide sheets and rolling skelps and presented recommendations on reducing the number of steps in the forging processes as compared to traditional ones, thanks to improved degree of working of the metal of the ingot axial zone, containing the most defects. As a result of introducing a modernized metal-saving technology of turbine disk forging at the Energomashspetstal Plant, a savings of 400 tons steel per year was achieved. This was reported by A. K. Onishchenko, E. V. Veretennikov, A. A. Leontyev and V. P. Bykov.

The report of B. S. Litvak, A. I. Nikolayev and A. A. Mishulin examined the principles of construction of CAD for optimal technological processes of forging on presses. A. I. Potapov (PO Uralmash) examined the possibility of using continuous-cast slabs as forging blanks after upsetting to a round cross section in a container. I. S. Zeltser (KII) reported on the results of research to lessen the formation of surface cracks during forging of stainless steels. A metal-saving fabrication technology for articles with wedge-shaped cross section was proposed in the work of K. K. Kaydarov and R. I. Serzhanov of the Pavlodarsk Industrial Institute. V. A. Tyurin and S. N. Svetlichnyy of the MISiS developed rational forging regimes on the model AKK-6000 forging layout and carried out an industrial-scale forging of pieces from ingots weighing up to 25 tons, resulting in better mechanical properties of the metal, lower initial mass of the ingot, and smaller machining tolerances.

Interest was aroused by the report of A. N. Anokhin, discussing the experience of the Energomashspetstal plant in using remnants and scraps resulting from the forging of large-sized pieces. The report of B. N. Berezovskiy and V. V. Glushko (Rostselmash plant/technical college) presented a method and a die for producing parts by cold radial reducing of pipe skelps. The reports devoted great attention to methods of improving the structure and chemical composition of steel in forging of large-size pieces. Devoted to these issues were the reports of A. K. Onishchenko and I. P. Seliverstova (TsNIITmash), in which a thermocyclomechanical form of machining was proposed to improve the grain structure and workability of forgings.

A number of reports presented new designs for production of cylindrical forged pieces. A wide-ranging discussion was stimulated by the reports of M. I. Bakhteyev and A. M. Kazarinov (PO Uralmash), in which universal stamping layouts were presented for fabrication of crankshaft blanks, as well as a layout for forging of cold-rolling forged rolls.

The conference was held in a lively creative atmosphere. The participants critically discussed the reports, relating them to the actual production conditions.New problems of forging technology were enunciated and incorporated in the resolution of the conference. The need was pointed out for reconciliation of the differences between the requirements of GOST 7062-79 and the technological capabilities of the equipment and measuring devices in use, which have become especially glaring since introduction of the state inspection of products of the forging and pressing departments. It is necessary to change the system of technical-economic planning indexes, so that introduction of progressive resource-sparing forging technology which improves the precision of the forged product (KVT) is profitable to the department.

In order to resolve these matters, it is necessary to form a temporary creative team of specialists from the technical colleges, research institutes, and enterprises of the USSR Ministry of Heavy Machinery.

The conference participants, observing the positive contribution of the journal KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO, mentioned the need for regular publication of survey articles, generalizing and comparing (in the USSR and in the West) new technological strategies, inventions, and forging technology processes that are under proposal, development, or introduction.

12717